EOCENE MOLLUSCAN PALEONTOLOGY OF THE WHITAKER PEAK AREA, LOS ANGELES AND VENTURA COUNTIES, CALIFORNIA

Richard L. Squires

Contributions in Science, Number 388
Natural History Museum of Los Angeles County
20 October 1987

ISSN 0459-8113

Natural History Museum of Los Angeles County
900 Exposition Boulevard
Los Angeles, California 90007

CONTENTS

ABSTRACT 1
INTRODUCTION 3
PREVIOUS WORK 3
MACROFOSSILS 3
STRATIGRAPHIC UNITS AND DEPOSITIONAL ENVIRONMENTS 5
AGE 10
CORRELATION 13
PALEOCLIMATE 14
PALEOBIOGEOGRAPHY 16
METHODS AND SYSTEMATIC MATERIALS 18
SYSTEMATICS 19
Phylum Coelenterata
Class Anthozoa
Order Scleractinia
Family Astrocoeniidae
Astrocoenia new species? aff. *A. portoricoensis* Vaughan, 1919 19
Phylum Annelida
Class Polychaeta
Order Sabellida
Family Serpulidae
Rotularia (*Rotularia*) *tejonense* (Arnold, 1910) 19
Phylum Mollusca
Class Scaphopoda
Family Dentaliidae
Dentalium stentor Anderson and Hanna, 1925 21
Class Gastropoda
Order Archaeogastropoda
Family Fissurellidae
Hemitoma (*Montfortia*) *cantonensis* new species 21
Family Trochidae
Monodonta (*Incisilabium*?) *piruensis* new species 22
Family Neritidae
Nerita (*Theliostyla*) *triangulata* Gabb, 1869 23
Velates perversus (Gmelin, 1791) 23
Order Mesogastropoda
Family Turritellidae
Turritella andersoni Dickerson, 1916 24
Turritella meganosensis protumescens Merriam and Turner, 1937 25
Turritella merriami Dickerson, 1913 25
Turritella buwaldana Dickerson, 1916 27
Turritella uvasana infera Merriam, 1941 27
Turritella uvasana applinae Hanna, 1927 28
Family Architectonicidae
Architectonica (*Stellaxis*) *cognata* Gabb, 1864 29
Family Cerithiidae
Bittium? *dumblei* (Dickerson, 1916) 29
?*Pseudovertagus* (*Pseudoaluco*) sp. 30
Benoistia cantonensis new species 30
Family Campanilidae
Campanile new species? 31
Family Calyptraeidae
Calyptraea diegoana (Conrad, 1855) 32
Credpidula new species? 32

Family Strombidae
Ectinochilus (*Macilentos*) *macilentus* (White, 1889) 32
Chedevillia saltonensis Squires and Advocate, 1986 33
Family Seraphsidae
Paraseraphs erraticus (Cooper, 1894) 33
Family Cypraeidae
Gisortia clarki Ingram, 1940 35
Family Naticidae
Crommium pinyonensis (Dickerson, 1914) 35
Eocernina hannibali (Dickerson, 1914) 36
Pachycrommium clarki (Stewart, 1927) 36
Amaurellina caleocia Vokes, 1939 37
Polinices (*Euspira*) *nuciformis* (Gabb, 1864) 37
Neverita (*Neverita*) *globosa* Gabb, 1869 37
Sinum obliquum (Gabb, 1864) 39
Family Cassidae
Galeodea (*Gomphopages*) *meganosensis* Vokes, 1939 39
Phalium (*Semicassis*) *tuberculiformis* (Hanna, 1924) 40
Family Ranellidae
Sassia bilineata (Dickerson, 1916) 40
Family Ficidae
Ficopsis remondii crescentensis Weaver and Palmer, 1922 41
Order Neogastropoda
Family Fasciolariidae
Clavilithes tabulatus (Dickerson, 1913) 41
Streptochetus californiana new species 41
Family Olividae
Pseudoliva dilleri Dickerson, 1914 42
Strepsidura ficus (Gabb, 1864) 42
Ancilla gabbi Cossmann, 1899 43
Olivella mathewsonii Gabb, 1864 43
Family Volutomitridae
Proximitra? *cretacea* Gabb, 1864 43
Family Tudiclidae
Pseudoperissolax blakei praeblakei Vokes, 1939 45
Family Volutidae
Cryptochorda (*Cryptochorda*) *californica* (Cooper, 1894) 45
Athleta roddai new species 46
Lyria andersoni Waring, 1917 47
Lyrischapa lajollaensis (Hanna, 1927) 47
Family Turridae
Fusiturricula (*Crenaturricula*) *crenatospira* (Cooper, 1894) 47
Surculites mathewsonii (Gabb, 1864) 48
Apiotoma californiana new species 48
Pleurofusia fresnoensis (Arnold, 1910) 49
Eopleurotoma whitakerpeakensis new species 49
Cryptoconus cooperi (Dickerson, 1916) 50
Family Conidae
Conus caleocius Vokes, 1939 50
Conus remondii Gabb, 1864 51
Conus hornii piruensis new subspecies 51
Order Cephalaspidea
Family Cylichnidae
Cylichnina tantilla (Anderson and Hanna, 1925) 53
Scaphander (*Mirascapha*) *costatus* (Gabb, 1864) 53
Family Pyramidellidae
?*Pyramidella preblei* Hanna, 1927 54

Class Bivalvia
Order Nuculoida
Family Nuculidae
Acila (*Truncacila*) *decisa* (Conrad, 1855) 54
Family Nuculanidae
Hilgardia? *parkei* (Anderson and Hanna, 1925) 54
Order Arcoida
Family Arcidae
Barbatia (*Barbatia*) cf. *B.* (*B.*) *morsei* Gabb, 1864 55
Barbatia (*Cucullaearca*) *cliffensis* Hanna, 1927 55
Family Glycymerididae
Glycymeris (*Glycymeris*) *rosecanyonensis* Hanna, 1927 55
Glycymeris (*Glycmerita*) *sagittata* (Gabb, 1864) 56
Order Mytiloida
Family Mytilidae
Brachidontes (*Brachidontes*) *cowlitzensis* (Weaver and Palmer, 1922) 56
Septifer (*Septifer*) cf. *S.* (*S.*) *elegans* Waring, 1917 56
Order Pterioida
Family Propeamussiidae
Propeamussiidae, indet. 57
Family Plicatulidae
Plicatula juncalensis new species 57
Family Ostreidae
Ostrea haleyi Hertlein, 1933 58
Ostrea stewarti Hanna, 1927 58
Ostrea cf. *O. stewarti* Hanna, 1927 59
Order Veneroida
Family Lucinidae
Miltha packi (Dickerson, 1916) 59
Claibornites diegoensis (Dickerson, 1916) 61
Family Fimbriidae
Fimbria new species? 61
Family Chamidae
Chama piruensis new species 62
Family Carditidae
Venericardia (*Pacificor*) *hornii lutmani* Turner, 1938 63
Venericardia (*Pacificor*) *aragonia joaquinensis* (Vokes, 1939) 63
Glyptoactis (*Glyptoactis*) *domenginica* (Vokes, 1939) 63
Glyptoactis (*Claibornicardia*) *sandiegoensis* (Hanna, 1927) 64
Family Crassatellidae
Crassatella uvasana Conrad, 1855 64
Family Cardiidae
Acanthocardia (*Schedocardia*) *brewerii* (Gabb, 1864) 65
Nemocardium linteum (Conrad, 1855) 65
Family Mactridae
Spisula merriami Packard, 1916 67
Family Solenidae
Solena (*Eosolen*) *novacularis* (Anderson and Hanna, 1928) 67
Family Tellinidae
Tellina (*Macaliopsis*) new species? aff. *T.* (*M.*) *rosa* (Hanna, 1927) 68
Family Psammobiidae
Gari texta Gabb, 1864 68
Gari new species? aff. *G. eoundulata* Vokes, 1939 68
Family Veneridae
Pitar (*Lamelliconcha*) *joaquinensis* Vokes, 1939 68
Callista (*Costacallista*) *hornii vokesi* new subspecies 69
Callista (*Macrocallista*) *domenginica* Vokes, 1939 70
Callocardia (*Nitidavenus*) *tejonensis* (Waring, 1914) 70

Order Myoida
Family Corbulidae
Corbula (*Caryocorbula*) *dickersoni* Weaver and Palmer, 1922 70
Corbula (*Caryocorbula*) *parilis* Gabb, 1864 71
Corbula (*Varicorbula*) *capayana* Vokes, 1939 71
Family Teredinidae
Teredo? sp. 71
Order Pholadomyoida
Family Pholadomyidae
Pholadomya (*Bucardiomya*) *givensi* Zinsmeister, 1978 71
Phylum Echinodermata
Class Stelleroidea
Order Indeterminate
Ophiuroid 72
Class Echinoidea
Order Spatangoida
Family Schizasteridae
Schizaster cf. *S. lecontei* Merriam, 1899 72
LOCALITIES 72
ACKNOWLEDGMENTS 80
LITERATURE CITED 80

EOCENE MOLLUSCAN PALEONTOLOGY OF THE WHITAKER PEAK AREA, LOS ANGELES AND VENTURA COUNTIES, CALIFORNIA

Richard L. Squires[1]

ABSTRACT. The paleontology and stratigraphic distribution of the macrofossils in the early through early middle Eocene age (Ypresian and lowermost Lutetian) strata in the Whitaker Peak area, lower Piru Creek, Los Angeles and Ventura counties, southern California, are described in detail. Ninety-nine taxa, mostly molluscs, are recorded from 70 localities.

Illustrations, synonymies, primary type material information, West Coast molluscan "stage" ranges, geographic distributions, local occurrences, and remarks are provided for the taxa, whieh include one colonial coral, one calcareous annelid tube, one scaphopod, 56 gastropods, 38 bivalves, one ophiuroid, and one spatangoid. Eleven new species or subspecies are described and named: (gastropods) *Hemitoma* (*Montfortia*) *cantonensis* new species, *Monodonta* (*Incisilabium*?) *piruensis* new species, *Benoistia cantonensis* new species, *Streptochetus californiana* new species, *Athleta roddai* new species, *Apiotoma californiana* new species, *Eopleurotoma whitakerpeakensis* new species, *Conus hornii piruensis* new species, (bivalves) *Plicatula juncalensis* new species, *Chama piruensis* new species, and *Callista* (*Costacallista*) *hornii vokesi* new subspecies. The new species of *Streptochetus* is the first record of this genus on the West Coast. *Athleta roddai* new species and *A. lawsoni* (Dickerson) are the only records of this genus on thc West Coast. The new species of *Monodonta, Benoistia,* and *Chama* are the earliest records of these genera on the West Coast. Six possible new species of the following genera also are discussed: (coral) *Astrocoenia,* (gastropods) *Campanile, Crepidula,* (bivalves) *Fimbria, Tellina* (*Macaliopsis*), and *Gari.*

The strata, which have received little previous study, include a 900-m-thick siltstone unit overlain by a 790-m-thick sandstone unit. The siltstone unit is assigned to the Juncal Formation and the sandstone unit is tentatively assigned to the Matilija Sandstone.

The Juncal Formation unconformably overlies the pre-Tertiary Whitaker Peak granodiorite. In a vertical sense, half of the Juncal Formation is a transgressive sequence that was coincident in time with a major global sea-level rise (TE1.2). The sequence grades vertically upward from transgressive lag, to nearshore marine, to transition-zone deposits. There are scattered lenses of channel-lag, storm accumulations of warm-water, shallow-marine fossils in the nearshore marine and lower part of the transition-zone deposits. Most of the fossils have undergone only a small distance of postmortem transport and represent indigenous death assemblages. This lower half of the Juncal Formation contains molluscs indicative of the West Coast provincial molluscan "Capay Stage" (early Eocene), calcareous nannofossils indicative of CP9 through CP11 zones (early Eocene), planktonic foraminifera indicative of P8 Zone (early Eocene), and benthic foraminifera indicative of early Eocene time. The molluscan fauna in this portion of the Juncal Formation contains many Old World Tethyan or Tethyan-affinity, warm-water faunal elements (e.g., *Campanile, Gisortia, Velates perversus, Fimbria, Clavilithes*). Many, including most of the new species described in this report, show close morphological affinities with Anglo-Paris Basin Eocene species. Some of these faunal elements, including nearly all of the genera of the new species described in this report, immigrated for the first time into Californian waters during "Capay" time. This major influx coincided with the TE1.2 global sea-level rise and possibly the warmest time of the Cenozoic. The dispersal route of these Tethyan forms into western North America was via a seaway, probably in the southern Central American region.

The upper half of the Juncal Formation and overlying Matilija Sandstone? form a regressive/progradational sequence that was coincident in time with a major global sea-level fall (TE2.1). The sequence consists of transition-zone deposits that interfinger laterally to the west with fan-delta turbidites. Fossils are sparse. This sequence is continued in the overlying Matilija Sandstone? with vertical gradation from delta-front, to tidal-flat, to braided-river deposits. Fossils are sparse, but locally there are channel-lag storm accumulations of warm-water, shallow-marine molluscs in the delta-front deposits. This regressive/progradational sequence contains molluscs indicative of the West Coast provincial molluscan "Domengine Stage" (late early through early middle Eocene). One new subspecies of gastropod (*Conus hornii piruensis*) was found in the Matilija Sandstone?.

The presence of several of the molluscs in the "Capay Stage" portion of the Juncal Formation extends their stage ranges. Determination of the age of the formation in this area also allows, for the first time, detailed correlations with other West Coast Eocene formations from San Diego, California to southwestern Oregon. The Juncal Formation and Matilija Sandstone? in the study area are strikingly similar in stratigraphic position, lithology, paleoenviron-

1. Department of Geological Sciences, California State University, Northridge, California 91330, and Research Associate, Invertebrate Paleontology, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, California 90007.

Contributions in Science, Number 388, pp. 1-93
Natural History Museum of Los Angeles County, 1987

ISSN 0459-8113

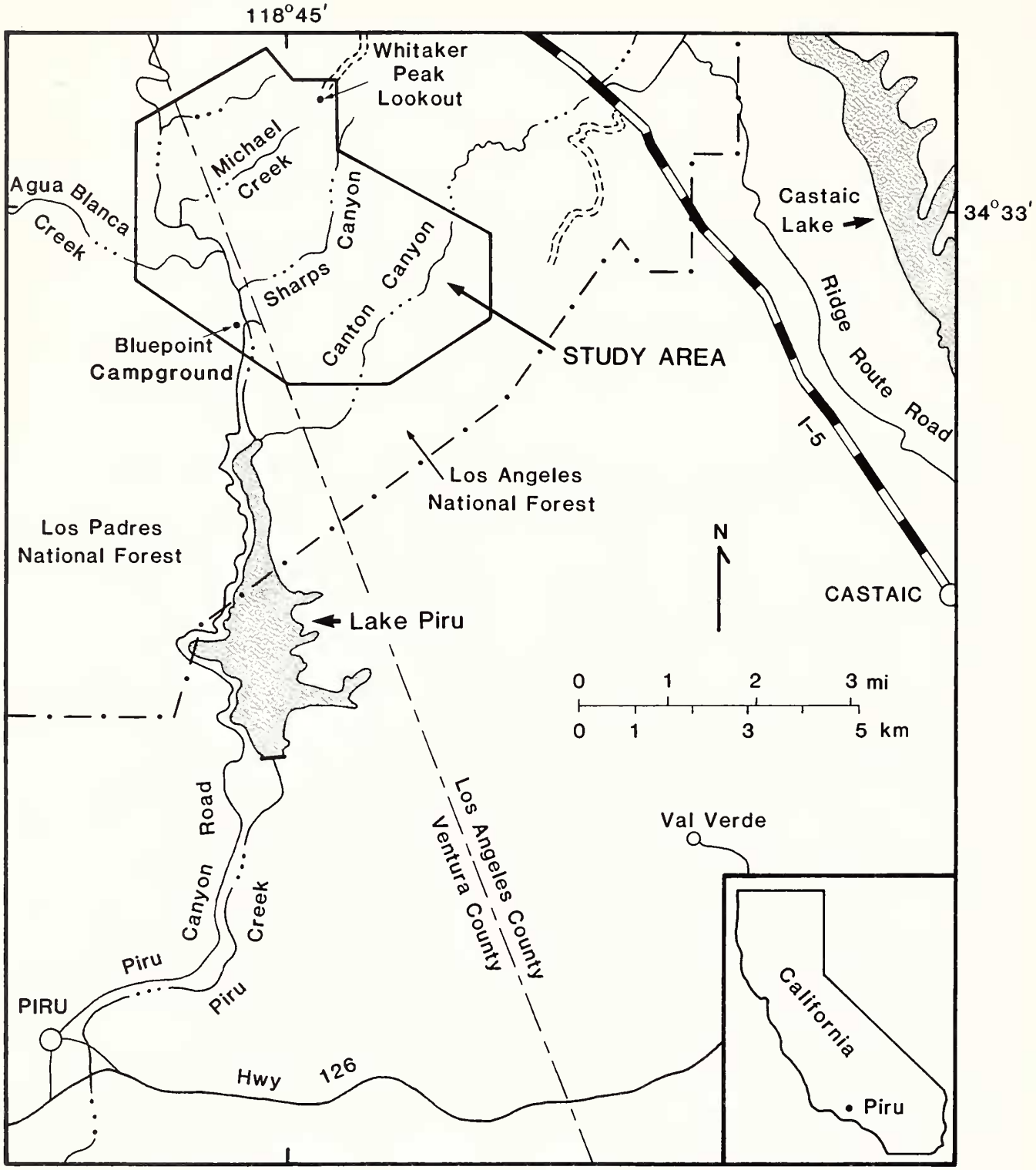


Figure 1. Index map showing the study area in the Whitaker Peak area, lower Piru Creek, Los Angeles and Ventura counties, southern California.

ments, and faunal content to the *Turritella uvasana infera* and *T. uvasana applinae* deposits, respectively, in the Pine Mountain area, 26 km (16 mi.) west of the Whitaker Peak area.

INTRODUCTION

The Eocene strata in the Whitaker Peak area, lower Piru Creek (Figs. 1 and 2), are fairly well exposed and locally rich in molluscan fossils, yet the strata have received little in the way of detailed geologic studies. Reasons for this must include 1) closure of the area during fire season, 2) frequent closures of the road into the area during the rainy season, 3) remoteness of the fossil-bearing beds, 4) steepness of the terrain, 5) difficulty in getting across Piru Creek during high-runoff times, and 6) oppressive heat in the summertime. Effectively, one has about four months or less per year in which to conduct fieldwork.

During the past 11 years, I have been able to accumulate nearly 60 days of fieldwork involving geologic mapping, strata descriptions, and fossil collecting. Although the main emphasis of this present report is the analysis of the molluscan taxa, the nature of my fieldwork allowed me to include, based on firsthand experience, the geologic mapping, stratigraphy, depositional environments, and biostratigraphy of the strata. The objectives of this report are to 1) tabulate the molluscs and other macrofossils, 2) provide synonymies and illustrations of the species, 3) refine the taxonomy of certain known species and describe eight new gastropods and three new bivalves, 4) establish the local molluscan biostratigraphy, 5) determine the age and correlation of each main stratigraphic unit, 6) interpret the paleoenvironments and biogeography of the macrofauna, and 7) refine the West Coast molluscan "Stage" ranges of the taxa.

The early through early middle Eocene strata in the study area are herein assigned to the Juncal Formation and to the overlying Matilija Sandstone? (Figs. 3–5). The assignment of the lower part of the section in the study area to the Juncal Formation was first proposed by Squires (1986) and Squires and Yamashiro (1986). Tentative assignment of the upper part of the section to the Matilija Sandstone? is proposed in this report for the first time. Strata crop out along the western and southern flanks of Whitaker Peak. Outcrops are well exposed along creek beds and along some south-facing slopes. Extensive cover can occur along ridge tops and north-facing slopes. Best exposures are in Canton Canyon and Piru Creek.

Macrofossils, which are mostly molluscs, are most abundant near the basal portions of both the Juncal Formation and Matilija Sandstone?. Preservation is usually poor to fair.

This study is only the second one in the last 50 years that involves a detailed analysis of an early Eocene ("Capay Stage") macrofossil assemblage on the West Coast. The macrofauna in the lower part of the Juncal Formation was previously not known to be of "Capay" age. Several of the molluscs are new species and several are genera that previously had not immigrated into the West Coast region. The results of this study solidly reconfirm that there was a close affinity between West Coast early Eocene macrofossil faunas and those of the Old World Tethyan biogeographic province, in general, and the Anglo-Paris Basin region, in particular.

PREVIOUS WORK

There is little published or unpublished geologic information on the Whitaker Peak area, which is in the Piru Mountains, a geomorphic and structural area named by Bailey and Jahns (1954). Generalized geologic maps can be found in Clements (1937), Crowell (1954), Scott, Ritter, and Knott (1968), the Los Angeles Sheet of the Geologic Map of California (Jennings and Strand, 1969), and Dibblee (1982).

More detailed geologic mapping and stratigraphic work in the study area has been done by Kriz (1947), Scanlin (1958), Anderson (1960), Shepard (1960), and Squires (1977). Reconnaissance petrologic and/or paleogeographic work can be found in Sage (1973) and Howell (1974, 1975a, 1975b). Depositional environment studies of the Juncal Formation can be found in Squires and Yamashiro (1986) and Yamashiro (1987). Depositional environment studies of the Matilija Sandstone? can be found in Squires (1977), Yamashiro and Squires (1986), and Yamashiro (1987).

Early workers made only brief mention of some of the molluscs (Kriz, 1947; Anderson, 1960; Shepard, 1960) or of the benthic foraminifera (Howell, 1974). The first molluscan biostratigraphic work in the study area was done by Squires (1976, 1977) on the sandstone unit, assigned to the Matilija Sandstone? in this present report. Preliminary findings on the fauna, molluscan biostratigraphy, and age of the siltstone in the lower part of the Juncal Formation have been reported by Squires (1985, 1986) and Squires and Yamashiro (1986).

MACROFOSSILS

Ninety-nine taxa, 96 percent of which are molluscs, were identified from the Juncal Formation and overlying Matilija Sandstone?, Whitaker Peak area. Taxa identified to species or subspecies include one colonial coral, one calcareous annelid tube, one scaphopod, 53 gastropods, 35 bivalves, and one spatangoid. Three gastropods and two bivalves are identified only to genus. One bivalve could only be identified to the family level, and an ophiuroid could only be identified to the order level. All of these taxa are illustrated in Figures 6 through 130. Other taxa, too poorly preserved for even generic determination, are a solitary scleractinian coral, an encrusting bryozoan, brachyuran fragments, echinoid fragments, a myliobatoid tooth, a leaf fossil, and scattered *Teredo*?-bored wood fragments.

The identifications of the species and subspecies studied in this report are based on published figures and descriptions and selected comparisons with type specimens and non-type specimens on deposit at 1) Natural History Museum of Los Angeles County, 2) University of California, Museum of Paleontology, Berkeley, 3) University of California, Museum of Paleontology, Riverside, and 4) California State University, Northridge.

Macrofossils were collected at 70 localities in the Whitaker Peak area. All of the localities are described in the "Localities" section, and the geographic position and relative stratigraphic position of each one is shown in Figures 131 through 135.

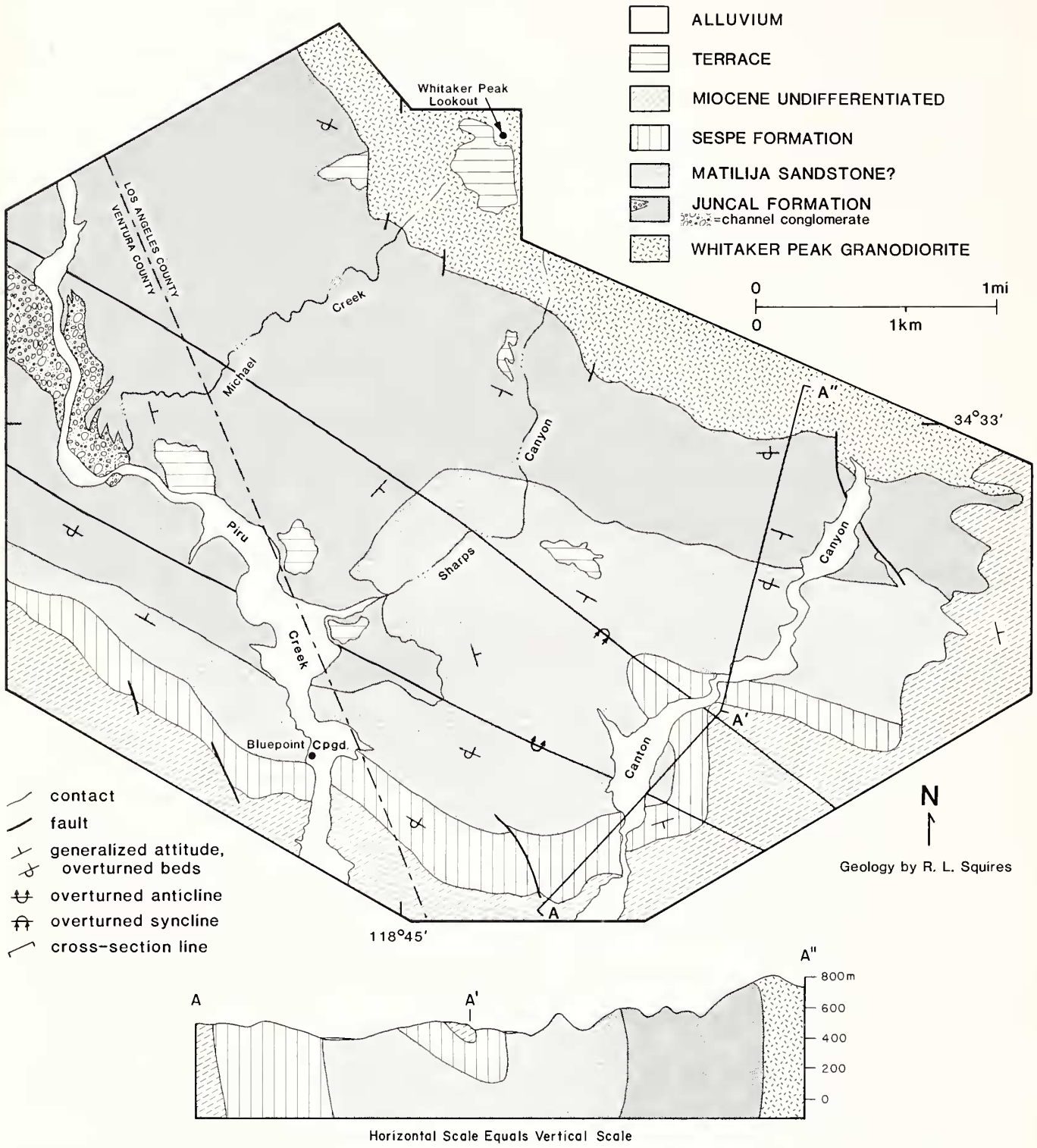


Figure 2. Geologic map and geologic cross section of the Whitaker Peak area, Los Angeles and Ventura counties, southern California.

Eleven new species or subspecies were found in the course of this present study.

STRATIGRAPHIC UNITS AND DEPOSITIONAL ENVIRONMENTS

The Eocene section in the Whitaker Peak area consists of the Juncal Formation, a 900-m-thick predominantly siltstone unit (=unit E_1 of Squires, 1977); and the overlying Matilija Sandstone?, a 790-m-thick sandstone unit (=unit E_2 of Squires, 1977). The section unconformably overlies the pre-Tertiary Whitaker Peak granodiorite and is unconformably overlain by the Eocene?/Oligocene nonmarine Sespe Formation (Fig. 2). The Eocene section underlies the Sespe Formation with a 15° angular unconformity (Yamashiro and Squires, 1986). The amount of pre-Sespe erosion increases westwardly.

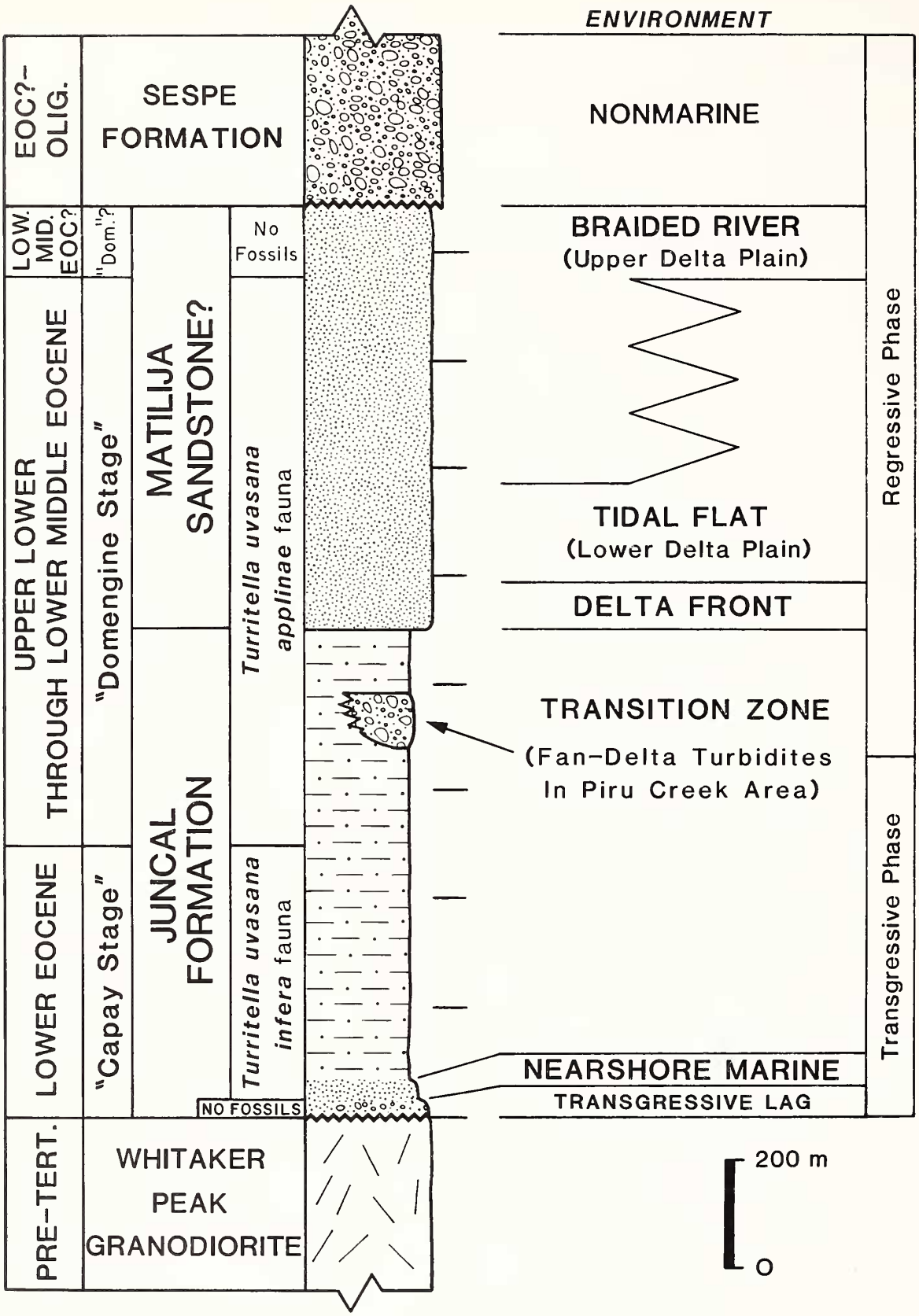
Based on sedimentologic and lithologic features, comparative studies of modern and ancient sedimentary sequences, and ecology of representative genera of molluscs, the following deposits have been recognized in this Eocene section: transgressive lag, nearshore marine, transition zone interfingering laterally to the west with fan-delta turbidites, delta front, tidal flat, and braided river (Squires and Yamashiro, 1986; Yamashiro and Squires, 1986; Yamashiro, 1987). Correlation of the Juncal Formation and Matilija Sandstone? to these various deposits is shown in Figure 3. In a vertical sense, most of the Juncal Formation consists of a transgressive sequence in which shallow-marine deposits are overlain by deeper, offshore marine deposits (Fig. 3). Deposition was coincident with a global sea-level rise (TE1.2 cycle of Vail and Hardenbol, 1979) (Fig. 4). The upper part of the Juncal Formation and the Matilija Sandstone? consist of a regressive/progradational sequence in which offshore marine deposits are overlain by shallower, deltaic deposits, culminating in nonmarine deposits (Fig. 3). Deposition was coincident with a global sea-level fall (base of TE2.1 cycle of Vail and Hardenbol, 1979) (Fig. 4).

Juncal Formation. The thin veneer of transgressive-lag deposits at the base of the Juncal Formation is usually between 1 and 4 m thick. In the vicinity of CSUN localities 812 and 815 it is not present, and in the vicinity of CSUN localities 827 and 853 it is 8 m thick. The lag is unfossiliferous and is usually pebble-to-boulder conglomeratic sandstone, which consists mostly of angular to poorly rounded pieces of the underlying granodiorite bedrock. About 1.6 km (1 mi.) west of Canton Canyon (Fig. 2), in the area between CSUN localities 836 and 841, however, the transgressive lag consists mostly of quartzite and granite clasts, usually subangular and cobble size. About 50 m east of locality 841, there are well-rounded boulders of quartzite and granite up to 1 m in diameter. This is the only place where such large, well-rounded clasts were found.

Erosion and disaggregation of the Whitaker Peak granodiorite took place prior to the marine transgression. The resulting residue was buried and preserved by the transgressing marine waters. In the area about 1.6 km (1 mi.) west of Canton Canyon, the deposits of a braided river were also preserved. The quartzite and granite clasts within these river deposits had been transported a considerable distance.

Transgressing marine waters are capable of much erosion in the coastal environment (Swift, 1968), and such erosion would explain the thinness and local absence of the transgressive-lag deposits. The rocky residue of disaggregated granodiorite would have made a rocky littoral environment along the advaneing shoreline. There are some faunal indications that this environment did exist. Throughout the study area, in the nearshore-marine deposits and overlying transition-zone (transgressive phase) deposits, there are genera whose modern-day analogs are associated with rocky shorelines. These genera are *Monodonta, Barbatia, Chama, Plicatula,* and *Septifer.* There are also sea-urchin fragments and a few encrustations of coralline red algae. *Monodonta* is mostly intertidal among rocks (Abbott and Dance, 1982). *Barbatia* is byssally attached and usually wedged in among rocks or colonial corals (Stanley, 1970). *Chama* usually inhabits rocky shores and coral reefs, as well as sublittoral-fringe environments (Kennedy, Morris, and Taylor, 1970; Bernard, 1976). *Plicatula* is commonly attached to flat surfaces on rocks or in rock crevices (Keen, 1971). *Septifer* commonly lives in the littoral environment on rocks (Abbott and Dance, 1982).

Overlying and gradational with the transgressive-lag deposits are the nearshore-marine deposits. In the vicinity of CSUN locality 812, they directly overlie granodiorite bedrock. In most places, the deposits are usually between 1 and 3 m thick. In the vicinity of CSUN localities 362, 827, and 839, they are 10 to 15 m thick, and they are 9 m thick in the area about 1.6 km (1 mi.) west of Canton Canyon. The nearshore-marine deposits are of foreshore/shoreface origin and consist of fine or medium, well-sorted sandstone. Hereafter in this report, they are also referred to as the nearshore sandstone. Locally, there are vertical *Ophiomorpha* burrows. There are scattered lenses of shallow-marine fossils, and collections were made at every lens that was found. These lenses are the following CSUN localities: 362, 805, 806, 812, 825, 838, 841, 848, 849, 850, 852, and 853. In terms of faunal composition, nearly every species found in the nearshore sandstone also occurs in the transition-zone deposits. This would be expected because most of the organie remains in the nearshore sandstone were storm-derived from the slightly deeper and laterally adjacent transition-zone environment. The nearshore sandstone, however, does have the following distinguishing paleontologic aspects. Pieces of *Teredo*?-bored petrified wood are fairly common. The driftwood accumulated along the coastline. At locality 825, a 12-cm-thick encrustation of coralline red algae was found in a concretion. The algae indicate fairly clear, sunlit coastal waters. At locality 362, articulated specimens of *Miltha packi* were found alongside numerous storm-derived shallow-marine molluscs. These large robust bivalves are *in situ* because they are articulated and they have withstood the stressful environment of the coastline. Allen (1958), Stanley (1970), and Jackson (1970) found that large lucinoids like the infaunal *Miltha* commonly live in areas characterized by a high degree of ecological stress, such as fluctuations in salinity and tem-


ENVIRONMENT
EOC?–
OLIG.
SESPE
FORMATION
NONMARINE
LOW.
MID.
EOC?
"Dom."?
No
Fossils
BRAIDED RIVER
(Upper Delta Plain)
UPPER LOWER
THROUGH LOWER MIDDLE EOCENE
"Domengine Stage"
MATILIJA
SANDSTONE?
Turritella uvasana
applinae fauna
TIDAL FLAT
(Lower Delta Plain)
DELTA FRONT
TRANSITION ZONE
(Fan–Delta Turbidites
In Piru Creek Area)
JUNCAL
FORMATION
Turritella uvasana
infera fauna
LOWER EOCENE
"Capay Stage"
NEARSHORE MARINE
TRANSGRESSIVE LAG
NO FOSSILS
PRE–TERT.
WHITAKER
PEAK
GRANODIORITE
200 m
0
Regressive Phase
Transgressive Phase

perature. Jackson (1970), furthermore, found that lucinoids today are especially dominant in nearshore areas in the tropics. Locality 362 may have been near the mouth of a river, as also indicated by the thick section of sandstone there.

About 1.6 km (1 mi.) west of Canton Canyon, the nearshore sandstone contains well-bedded, small carbonized wood fragments that can make up as much as 20 percent of the rock. The amount of wood fragments decreases upsection. Lenses of shallow-marine fossils can be interbedded with the carbonized wood fragments, as at CSUN localities 805, 806, 838, and 841. These lenses are characterized by abundant *Turritella uvasana infera,* large *Venericardia* (*Pacificor*) *aragonia joaquinensis,* and articulated *Miltha packi.* The presence of these sturdy-shelled molluscs indicates nearshore, shallow-marine conditions. *Venericardia* (*P.*) *aragonia joaquinensis* also occurs in shoreline deposits near the base of the Llajas Formation in Simi Valley, California (Squires, 1984). The presence of abundant carbonized wood fragments in this part of the Whitaker Peak area suggests the proximity of the mouth of a river. This river would have been the same one that transported the large clasts of quartzite and granite into the area just east of locality 841, as discussed under the transgressive-lag deposits. The nearshore sandstone is thick in this area because increased deposition took place where the river emptied into the ocean. *Miltha packi* would have been well suited in this area, as well as near locality 362, because of its tolerance for the fluctuating salinity that the rivers would have caused.

Lenses of shallow-marine fossils also occur in fine sandstone that directly overlies the carbonized wood-fragment sandstone, as at localities 848, 849, and 850. In this area, the lenses are characterized by *Velates perversus.* Numerous specimens were found at locality 850, and they constitute a growth series. Locality 850 also is characterized by some large (up to 11 cm in height) *Miltha packi* valves and sea-urchin fragments. The presence of these specimens indicates, once again, nearshore shallow-marine conditions. In the case of *V. perversus,* any postmortem transport has been minimal. *Velates perversus* also occurs in shoreline deposits near the base of the Llajas Formation in Simi Valley, California (Squires, 1984).

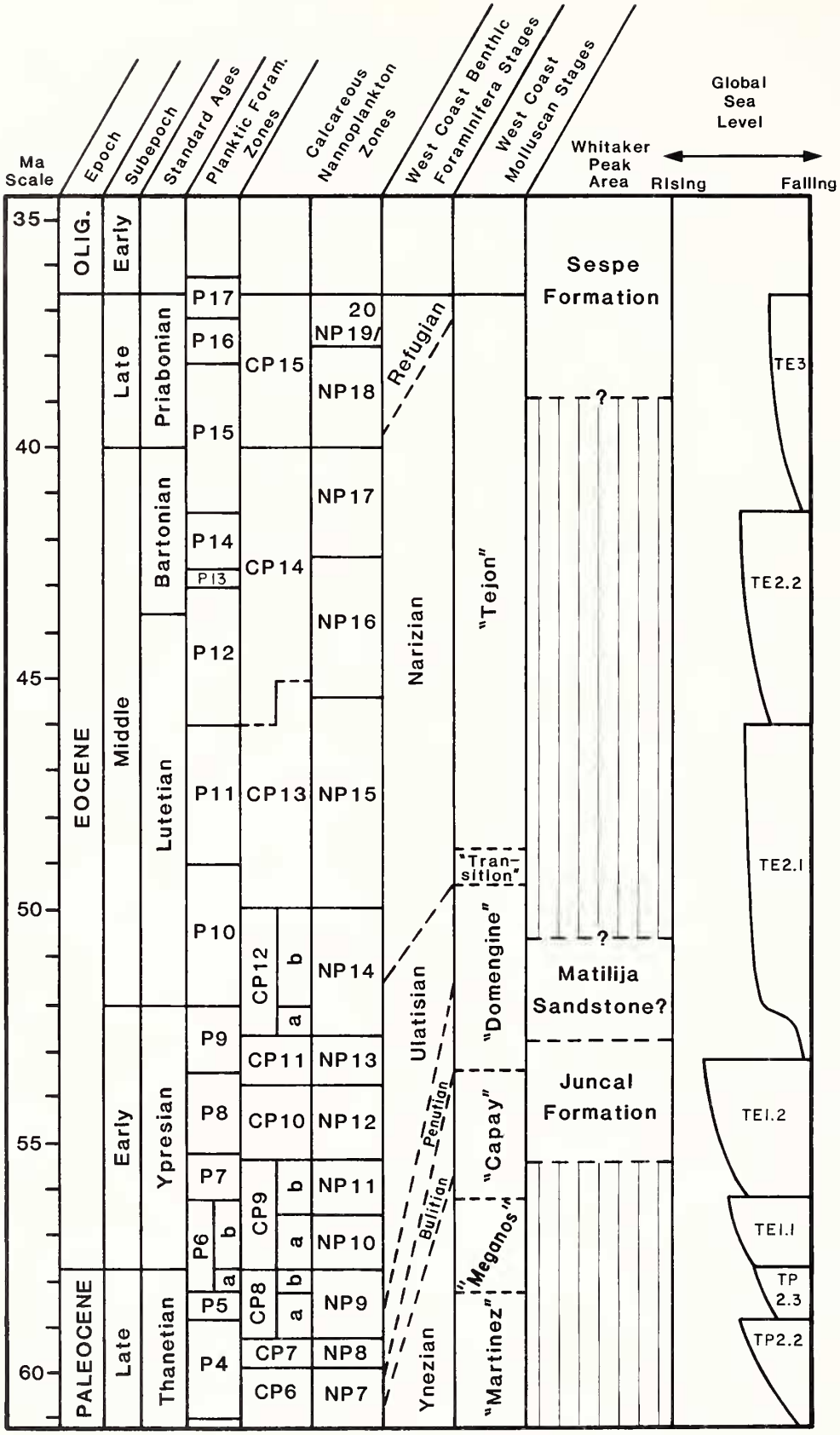
The nearshore sandstone grades vertically upward into transition-zone deposits that formed in shelf-like depths. The lower 500 m consists of interbedded offshore siltstone (85 percent), nearshore fine to medium sandstone (10 percent), and lenses of macrofossils (5 percent). The amount of sandstone interbeds and lenses of macrofossils decrease upsection. Most of the fossil localities are in the lower 60 m. Macrofossil lenses are usually about 30 to 50 cm thick and extend laterally from 1 to 20 m. They represent channel-lag storm accumulations. At some localities the coarsest material is at the bottom of the channel. At a few localities, coquina beds of fossil hash are present. Most fossils in the transition-zone deposits have undergone only a small distance of transport and constitute indigenous death assemblages. In nearly every lens, some of the fossils show preservation of delicate features such as protoconchs, outer lips, and ribs. Some even have partial growth series, with only the early juvenile individuals lacking. Nearly all the bivalves are single valves, but at locality 824 a large specimen of *Venericardia* (*Pacificor*) *hornii lutmani* was found articulated. Also, at locality 816, a specimen of *Pholadomya* (*Bucardiomya*) *givensi* was found articulated.

Taxonomic composition of the macrofossil-bearing lenses is variable. Collections made at 41 localities from these 500 m of strata yielded numerous shallow-marine gastropods and bivalves, as well as specimens of discocyclinid foraminifera, calcareous annelid tubes, a few colonial corals, and a few spatangoid echinoids. About 60 percent or 25 of these 41 localities, have five or fewer species of macrofossils. At localities 359, 827, and 845, however, 20 to 30 species were found. Species that characterize the lower 500 m of the transition-zone deposits are *Turritella uvasana infera, T. andersoni, Cylichnina tantilla, Clavilithes tabulatus,* and ostreid fragments.

Squires (1984) tabulated the bathymetry of extant molluscan genera that were found in the Eocene Llajas Formation, Simi Valley, California. Fifty percent of these genera are the same as those found in the transgressive-phase transition-zone deposits of the Whitaker Peak area. These genera are *Dentalium, Architectonica, Calyptraea, Conus, Galeodea, Lyria, Neverita* (*Neverita*), *Pseudoliva, Turritella, Acanthocardia, Acila* (*Truncacila*), *Brachidontes, Callista* (*Costacallista*), *Corbula* (*Caryocorbula*), *Gari, Glycymeris, Nemocardium, Ostrea, Pitar* (*Lamelliconcha*), *Solena,* and *Teredo.* Based on the tabulated data by Squires (1984), the extant genera in these transition-zone deposits would most commonly occur today in seas between 10 and 45 m depth. This range was calculated by averaging the lowest and highest, most frequently reported depth ranges of the genera. The following additional extant genera in these deposits also support this depth range. *Monodonta, Barbatia, Chama, Plicatula,* and *Septifer* commonly inhabit littoral and sublittoral fringe environments, as previously mentioned in the discussion of the transgressive-lag deposits. *Neverita* (*Neverita*) *globosa* is apparently closely related to *Neverita* (*Glossaulax*) *reclusiana* (Givens and Kennedy, 1976; Marincovich, 1977), which occurs today in depths from 0 to 50 m (Marincovich, 1977). *Bittium* is common in sublittoral depths near rocks (McLean, 1978). *Campanile* lives today most commonly in subtidal depths of approximately 3 m. It also can be intertidal (Houbrick, 1981). *Montfortia* lives on gravelly bottoms in depths of 18 to 73 m (Keen, 1971). *Pseudovertagus* (*Pseudovertagus*) lives in rubble areas from low tide mark to 9 m depth (Houbrick, 1978). *Fimbria* lives in shallow water, 5 to 20 m depth (Abbott and Dance, 1982). The hermatypic

←

Figure 3. Stratigraphic column of the Eocene strata in the Whitaker Peak area, showing West Coast molluscan stages, local faunas, and depositional environments.


Ma Scale
Epoch
Subepoch
Standard Ages
Planktic Foram. Zones
Calcareous Nannoplankton Zones
West Coast Benthic Foraminifera Stages
West Coast Molluscan Stages
Whitaker Peak Area
Global Sea Level
Rising
Falling
35
40
45
50
55
60
OLIG.
EOCENE
PALEOCENE
Early
Late
Middle
Early
Late
Priabonian
Bartonian
Lutetian
Ypresian
Thanetian
P17
P16
P15
P14
P13
P12
P11
P10
P9
P8
P7
P6
P5
P4
CP15
CP14
CP13
CP12
CP11
CP10
CP9
CP8
CP7
CP6
20
NP19/
NP18
NP17
NP16
NP15
NP14
NP13
NP12
NP11
NP10
NP9
NP8
NP7
Refugian
Narizian
Ulatisian
Penutian
Bulitian
Ynezian
"Tejon"
"Transition"
"Domengine"
"Capay"
"Meganos"
"Martinez"
Sespe Formation
Matilija Sandstone?
Juncal Formation
TE3
TE2.2
TE2.1
TE1.2
TE1.1
TP 2.3
TP2.2

colonial coral *Astrocoenia* also is present in the transgressive-phase transition-zone deposits. Today, it lives in depths from 0 to 50 m (Wells, 1945).

Several extinct taxa of fossils in these 500 m of transition-zone deposits are also indicative of shallow depths. The presence of *Turritella andersoni, T. meganosensis protumescens,* and ostreid fragments, in addition to *Velates perversus, Miltha packi,* and *Venericardia* (*Pacificor*) *aragonia joaquinensis,* mentioned in the discussion of the nearshore sandstone, indicates shallow-water conditions. These same species, except for *Miltha packi,* are present in the zone of interfingering between coastal alluvial-fan facies and shallow-marine facies of the Eocene Llajas Formation, Simi Valley, California (Squires, 1984). Specimens of the discocyclinid foraminifera *Pseudophragmina* were found at localities 804, 815, 823, 837, 839, and 840. At locality 840 they are very large and are up to 1 cm in diameter. Discocyclinid foraminifera lived in very shallow water (below tide level to perhaps 100 m) (Durham, 1942a; Vaughan, 1945).

The mudstone facies at the base of the Juncal Formation in the Pine Mountain area, California, was interpreted as inner sublittoral deposits by Givens (1974), and it contains many of the same taxa as those from the transition-zone deposits of the Whitaker Peak area. The most important species are *Eocernina hannibali, Turritella andersoni, Turritella uvasana infera, Velates perversus, Miltha packi,* and *Venericardia* (*Pacificor*) *hornii lutmani.*

The upper 300 m of the transition-zone deposits of the Juncal Formation in the Whitaker Peak area consists of muddy siltstone (98 percent), nearshore fine or medium to coarse sandstone (2 percent), and rare lenses of macrofossils. The siltstone is muddier than that in the lower 500 m of the transition-zone deposits and, therefore, probably formed in somewhat deeper shelf-like depths. Only two macrofossil-bearing lenses were found (CSUN localities 363 and 828), and they represent channel-lag storm aecumulations. The condition of the fossils and the taxonomic composition are similar to those in the underlying 500 m, and they constitute indigenous death assemblages of shallow-marine molluscs. About 15 species of molluscs were found at each locality. *Turritella buwaldana* and *Conus remondii* characterize these transition-zone deposits. A few wood fragments and *Ophiomorpha* burrows are present locally.

The molluscs in the upper 300 m of the transition-zone deposits include the following extant genera whose bathymetry has been tabulated by Squires (1984): *Calyptraea, Conus, Phalium* (*Semicassis*), *Turritella, Acanthocardia, Callista* (*Costacallista*), *Corbula* (*Caryocorbula*), *Glycymeris, Nemocardium,* and *Pitar* (*Lamelliconcha*). These genera most commonly occur today at depths between 17 and 65 m. This range was calculated by averaging the lowest and highest, most frequently reported depth ranges of the genera. The following additional extant genera in these deposits also support this depth range. *Barbatia,* although commonly in intertidal depths could occur in waters as deep as 65 m, and *Spisula* most commonly lives in depths from 0 to 60 m (Abbott and Dance, 1982).

West of Michael Creek, in the vicinity of Piru Creek (Fig. 2), the upper 300 m of the transition-zone deposits thicken, interfinger with, and surround fan-delta turbidite deposits (Yamashiro, 1987). The surrounding transition-zone deposits consist of muddy siltstone and silty mudstone. The turbidite deposits consist of channelized rounded pebble-cobble, quartzite-granite conglomerate with interbedded coarse sandstone. These deposits are shown on Figure 2 as "channel conglomerate" within the upper part of the Juncal Formation. Macrofossils are extremely rare, but a few transported fragments of ?*Eocernina hannibali* were found in conglomerate beds exposed along the well-indurated cliffs of Piru Creek in the northwest corner of the study area. These fossils could not be extracted from the rock. Some carbonized wood fragments and *Ophiomorpha* burrows are also present in these beds. Howell (1974) also reported a submarine-fan origin for these beds.

The uppermost 100 m of the Juncal Formation in the study area are transition-zone-type sediments that were deposited just seaward of a delta front (Yamashiro and Squires, 1986; Yamashiro, 1987). These deposits are like those of the underlying transition-zone deposits and consist of siltstone with minor fine sandstone. Only one macrofossil locality was found (CSUN locality 230), and it yielded a single specimen of an ophiuroid in a concretion.

Matilija Sandstone? Overlying and gradational with the Juncal Formation is the Matilija Sandstone?. The lower 95 m consists of sandstone (95 percent), siltstone (5 percent), and uncommon lenses of macrofossils. These deposits accumulated on a delta front (i.e., equivalent to shoreface depths). As noted by Yamashiro and Squires (1986), the sandstone is laminated to bioturbated and constitutes an upward-coarsening sequence, fine at the base to medium at the top of the 95 m. Bioturbation is as high as 75 percent with *Ophiomorpha* burrows common. In places, the sandstone is carbonaceous and locally there are plant fragments 30 cm in length. The lenses of macrofossils usually occur in concretions that are about 60 cm in width, and the concretions are mostly confined to a 6-m-thick sandy siltstone layer that extends laterally for at least 300 m (about 1000 ft.) in the Sharps Canyon area (CSUN localities 219, 231, and 232). Locality 237, however, is a nonconcretionary 1-m-thick coquina bed that extends laterally for 2 m. The details of these four localities are discussed in Squires (1977). Locality 808 is on the west side of Piru Creek. All of these macrofossil-

←

Figure 4. Correlation of the Eocene strata, Whitaker Peak area, with West Coast Eocene molluscan "stages" (after Saul, 1983); millions of years scale (Ma), epochs, subepochs, standard ages, planktic foraminifera zones, and calcareous nannoplankton zones (all after Berggren et al., 1985); West Coast benthic foraminifera stages (after Poore, 1980); and global sea-level changes relative to planktic foraminifera zones (from Vail and Hardenbol, 1979).

bearing lenses represent channel-lag storm accumulations. Most of the fossils have undergone a moderate distance of transport. Although fairly delicate morphologic features such as ribs are well preserved, delicate protoconchs were not preserved. Partial growth series are scarce, except at locality 237 which is the stratigraphically lowermost locality in these delta-front deposits. Almost all the bivalves are single valves; however, at locality 231 a specimen of *Callocardia* (*Nitidavenus*) *tejonensis* and a specimen of *Corbula* (*Caryocorbula*) *parilis* were found articulated. Apparently, these specimens were transported while still alive.

Taxonomic composition of the macrofossil-bearing lenses is variable. Locality 237 is richest in terms of species diversity, with 32 species. Species that characterize the delta-front deposits are *Turritella uvasana applinae* and *Nemocardium linteum*.

Every extant molluscan genus in the upper part of the Juncal Formation also occurs in the delta-front deposits of the Matilija Sandstone?. This similarity would be expected because the molluscs in the delta-front deposits were storm-derived from the slightly deeper and laterally adjacent transition-zone environment.

Above the delta-front deposits are tidal sand-flat deposits that formed within a lower delta plain. These deposits are 100 m thick in the Canton Canyon area and 185 m thick about 1.5 km (0.9 mi.) to the west. They consist of sandstone (95 percent), coal lenses (5 percent), and uncommon macrofossils. The coarse sandstone is usually structureless and heavily bioturbated, but herringbone cross-bedding, planar cross-bedding, planar lamination, and scour-and-fill structures are common. The coal lenses in the upper part of the sandstone were formed in marsh environments (Yamashiro and Squires, 1986).

Macrofossils at all of the localities in the tidal-flat deposits (CSUN localities 28, 81, 214, 216, 220, and 246) except one (CSUN locality 809) consist exclusively of specimens of *Ostrea stewarti*. All of the specimens occur as float material. They are usually single valves and are abundant, but a few articulated speicmens were found at locality 246. Only a single, large articulated specimen was found at locality 216. At locality 809, which is in the lower part of the tidal-flat deposits, a concretionary lens of macrofossils yielded some ostreid fragments, carbonized wood fragments, and internal molds of *Nerita* (*Theliostyla*) *triangulata, Turritella uvasana applinae*?, and ?*Eocernina hannibali*.

The articulated specimens of *Ostrea* indicate that they were indigenous to the tidal-flat environment. The abundant of the specimens at most of the localities suggests that they may have formed oyster banks. The tidal-flat environment that these oysters lived in was subjected to brackish-water conditions because the tidal-flat deposits interfinger with and are overlain by braided-river deposits. Some modern species of *Ostrea* can tolerate brackish-water conditions (Morris, Abbott, and Haderlie, 1980). The presence of *Nerita* (*Theliostyla*) *triangulata* in the tidal-flat deposits also indicates brackish-water conditions. This brackish-water species also occurs in tidal-flat deposits in Eocene ("Domengine Stage") strata in Coalmine Canyon, near Coalinga, California (Vokes, 1939; Roush, 1986). In addition, it occurs in very shallow-marine or brackish-water deposits in unnamed Eocene strata in northern San Diego County, California (Givens and Kennedy, 1976) and in brackish-water deposits of the Eocene Delmar Formation, San Diego County (Givens and Kennedy, 1979). The presence of *Turritella* and ?*Eocernina* in the tidal-flat deposits of the Whitaker Peak area indicates that the contemporaneous shallow-marine environment was nearby and shallow-marine molluscs could be transported into the tidal-flat environment.

Overlying the 205-m-thick interval of interfingering between the tidal-flat deposits and the braided-river deposits is a 390-m-thick section of braided-river deposits (upper delta plain). About 1.5 km (0.9 mi.) west of Canton Canyon, the interval of interfingering thickens to 380 m and the braided-river deposits thin to 140 m (Yamashiro and Squires, 1986). The braided-river deposits consist of sandstone (80 percent), conglomerate (10 percent), and siltstone (10 percent). No fossils were found. The sandstone is usually massive and very coarse to conglomeratic, but in places it is channelized and trough cross-bedded. Locally, the sandstone grades upward into thin, red-and-green siltstone beds. The siltstone is interpreted to have accumulated in abandoned channels (Yamashiro and Squires, 1986). These sandstone-siltstone sequences are similar to localized fining-upward sequences described by Williams and Rust (1969) for braided-river channel-fill sediments.

AGE

The Juncal Formation in the Whitaker Peak area is early Eocene in age and the Matilija Sandstone? is late early through early middle Eocene in age. These age assignments are based on molluscs, calcareous nannofossils, and planktonic and benthic foraminifera. Assignment to European Standard Ages, various standard plankton zones, global sea-level changes, and West Coast provincial benthic foraminifera and molluscan stages is shown in Figure 4.

Clark and Vokes (1936) informally proposed five molluscan-based provincial Eocene "Stages"; namely, "Meganos," "Capay," "Domengine," "Transition," and "Tejon." They recognized two faunal zones in their "Capay Stage." Givens (1974) showed that their upper faunal zone of the "Capay" should be considered part of the "Domengine Stage," and he restricted the use of the "Capay Stage" to their lower faunal zone of the "Capay Stage." It is in this restricted sense that "Capay Stage" is used herein. Saul (1983) and Squires (1984) regarded the "Meganos Stage" as late Paleocene–early Eocene, the restricted "Capay Stage" of Givens (1974) as early Eocene, the "Domengine Stage" as late early through early middle Eocene, and the "Transition Stage" as middle Eocene. Squires (1984) regarded the "Tejon Stage" as late middle Eocene and/or late Eocene. Such ages are used for this present report (Figs. 3–5).

Prior to 1986, most workers (Clements, 1937; Kriz, 1947; Scanlin, 1958; Shepard, 1960; Howell, 1975b) regarded the age of all the strata discussed in this present report as middle

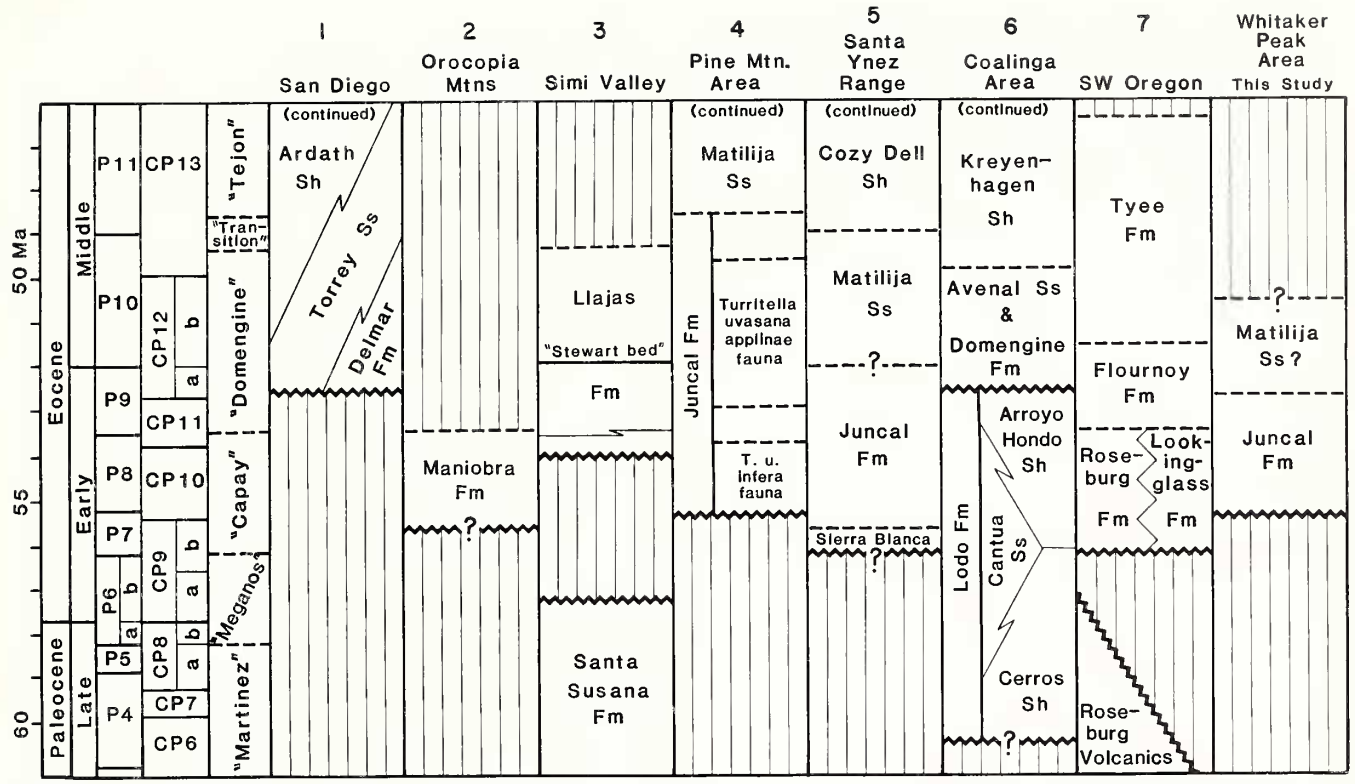


Figure 5. Correlation of the Eocene strata, Whitaker Peak area, with selected West Coast Eocene formations. Sources of information: 1) Eisenberg and Abbott, 1985. 2) Squires and Advocate, 1986; Squires, unpubl. data. 3) Squires, 1984. 4) Givens, 1974. 5) Link and Welton, 1982. 6) Poore, 1976. 7) Heller and Dickinson, 1985. See Figure 4 for information regarding biozones and "stages."

Eocene in age ("Domengine Stage") and questionably ranging upward into the "Transition" or "Tejon Stage" (Kriz, 1947). Their age assignments were based on a few macrofossils or microfossils, or on stratigraphic position. Anderson (1960) assigned all the strata to the late Eocene Cozy Dell and Coldwater formations, based on stratigraphic position. Squires (1976, 1977) assigned the Matilija Sandstone? portion (=his unit E_2) to the "Domengine" and "Transition stages," based on preliminary studies of molluscan assemblages.

Squires and Yamashiro (1986) preliminarily reported the age of the lower 500 m of the Juncal Formation in the Whitaker Peak area to be early Eocene ("Capay Stage") and the age of the upper 400 m to be late early through early middle Eocene ("Domengine Stage"). Yamashiro and Squires (1986) also preliminarily reported the age of the fossil-bearing part of the overlying Matilija Sandstone? deltaic complex to be late early through early middle Eocene ("Domengine Stage"). These age assignments were based on my most up-to-date work on the molluscs, the details of which are documented in this present report.

Although no fossils were found in the very thin, transgressive-lag deposits at the base of the Eocene section in the Whitaker Peak area, these deposits are gradational with the overlying, thin nearshore-marine deposits which contain fossils indicative of the "Capay Stage." It is reasonable to assign the transgressive-lag deposits to the "Capay Stage."

The nearshore-marine deposits and lower 500 m of the overlying transition-zone deposits contain macrofossils that have been reported (Clark and Vokes, 1936; Merriam and Turner, 1937; Turner, 1938; Vokes, 1939; Ingram, 1940, 1942; Merriam, 1941; Weaver, 1943; Verastegui, 1953; Givens, 1974; Zinsmeister, 1978; Saul, 1983; Squires, 1984; Squires and Advocate, 1986) elsewhere on the West Coast only from the "Capay Stage." These taxa are *Chedevillia saltonensis, Gisortia clarki, Pseudoliva dilleri, Turritella meganosensis protumescens, Ostrea haleyi, Pholadomya* (*Bucardiomya*) *givensi,* and *Venericardia* (*Pacificor*) *hornii lutmanii.*

Additional evidence for a "Capay" age for this part of the section is the joint occurrence of taxa whose stratigraphic ranges elsewhere on the West Coast overlap only within the "Capay Stage." *Rotularia* (*Rotularia*) *tejonense, Clavilithes tabulatus, Cryptochorda* (*Cryptochorda*) *californica, Cylichnina tantilla, Ectinochilus* (*Macilentos*) *macilentus, Eocernina hannibali, Ficopsis remondii crescentensis, Fusiturricula* (*Crenaturricula*) *crenatospira, Pachycrommium clarki, Pleurofusia fresnoensis, Sassia bilineata, Turritella merriami, Velates perversus, Acanthocardia* (*Schedocardia*) *brewerii,* and *Glycymeris* (*Glycymerita*) *sagittata* have their lowest stratigraphic occurrence in the "Capay Stage" (Turner, 1938; Vokes, 1939; Givens, 1974; Squires, 1984). *Turritella andersoni, Turritella uvasana infera,* and *Corbula* (*Varicor-*

bula) *capayana* have their highest stratigraphic occurrence in the "Capay Stage" (Vokes, 1939; Merriam, 1941; Saul, 1983; Squires, 1984).

The macrofossil assemblage in the nearshore marine up through the lower 500 m of the transition-zone deposits is herein referred to as the *Turritella uvasana infera* fauna (Fig. 3). This name is chosen because this taxon is both confined to and abundant in this part of the section.

The molluscan stage range of certain species can be extended based on their presence in the "Capay"-age *Turritella uvasana infera* fauna. *Galeodea* (*Gomphopages*) *meganosensis,* formerly reported (Clark and Woodford, 1927; Vokes, 1939; Keen and Bentson, 1944) as confined to the "Meganos Stage," can now be shown to occur also in the "Capay Stage." *Architectonica* (*Stellaxis*) *cognata, Paraseraphs erraticus, Strepsidura ficus, Corbula* (*Caryocorbula*) *dickersoni, Solena* (*Eosolen*) *novacularis,* and *Venericardia* (*Pacificor*) *aragonia joaquinensis,* formerly reported (Saul, 1983; Squires, 1984) as ranging no lower than uppermost "Capay," extend into the "Capay Stage" proper. *Amaurellina caleocia, Bittium? dumblei, Conus remondii, Lyria andersoni, Lyrischapa lajollaensis, Barbatia* (*Cucullaearca*) *cliffensis, Callista* (*Costacallista*) *hornii vokesi* new subspecies, *Claibornites diegoensis, Glyptoactis* (*Claibornicardia*) *sandiegoensis,* and *Pitar* (*Lamelliconcha*) *joaquinensis,* formerly reported (Clark, 1929; Vokes, 1939; Reinhart, 1943; Givens, 1974, 1979; Givens and Kennedy, 1976, 1979; Marincovich, 1977; Moore, 1983; Squires, 1983a, 1984) to be confined to the "Domengine Stage," have their lowest stratigraphic occurrence in the "Capay Stage." *Miltha packi,* formerly reported (Vokes, 1939; Givens and Kennedy, 1979; Deméré, Sundberg, and Schram, 1979) as ranging from "Domengine" through "Tejon" "stages," can now be shown to occur also in the "Capay Stage."

Three microfossil samples (CN1, =CSUN macrofossil locality 837, CN2, and CN3) from siltstone in the lower 500 m of the transition-zone deposits (see "Localities" and Figure 133 for geographic and relative stratigraphic positions) yielded age-diagnostic calcareous nannofossils, as well as planktonic and benthic foraminifera, and all are indicative of early Eocene age (Filewicz, 1986, pers. commun.; Thornton, 1986, pers. commun.). The results are incorporated into Figures 4 and 5.

Sample CN1 (=CSUN macrofossil locality 837) from approximately 40 m above the base of the Eocene section (Fig. 134) contained the following calcareous nannofossils: *Coccolithus formosus, Discoasteroides kuepperi, Sphenolithus moriformis, S. radians, Tribachiatus orthostylus,* and very rare *Discoaster lodoensis.* Filewicz (1986, pers. commun.) assigned this microfauna to the early Eocene *Tribrachiatus orthostylus* (CP10) Zone of Okada and Bukry (1980). CSUN macrofossil locality 837 also yielded the planktonic foraminifera *Globorotalia aragonensis* and *G. bullbrooki.* Thornton (1986, pers. commun.) assigned these species to the early Eocene Planktonic Zone P8 of Blow (1969). In addition, CSUN locality 837 yielded the benthic foraminifera *Marginulina mexicana* var. B and *Asterigerina crassaformis.* Thornton (1986, pers. commun.) assigned these species to the early Eocene Benthic Zone "C" (lower "Capay Stage") of Laiming (1940a, 1940b, 1943).

Sample CN2 from approximately 100 m above the base of the Eocene section (Fig. 133) contained the following calcareous nannofossils: *Coccolithus formosus, Discoaster diastypus, Discoasteroides kuepperi, Lophodolithus reniformis,* and *Tribrachiatus orthostylus.* Filewicz (1986, pers. commun.) assigned this microfauna to the early Eocene *Discoaster diastypus* (CP9) to *Tribrachiatus orthostylus* (CP10) zones of Okada and Bukry (1980). Sample CN2 also yielded the benthic foraminifera *Siphonina* sp. cf. *S. wilcoxensis.* Thornton (1986, pers. commun.) assigned this species to the early Eocene Benthic Zone "C" (lower "Capay Stage") of Laiming (1940a, 1940b, 1943).

Sample CN3 from approximately 150 m above the base of the Eocene section (Fig. 133) contained the following calcareous nannofossils: *Coccolithus formosus, Discoaster lodoensis, Discoasteroides kuepperi, Helicosphaera seminulum, Sphenolithus moriformis, S. radians,* and very rare *Coccolithus crassus.* Filewicz (1986, pers. commun.) assigned this microfauna to the early Eocene *Discoaster lodoensis* (CP11) Zone of Okada and Bukry (1980). Sample CN3 also yielded the planktonic foraminifera *Globorotalia broedermanni* and *G. formosa gracilis.* Thornton (1986, pers. commun.) assigned these species to the early Eocene Planktonic Zone P8 of Blow (1969). In addition, sample CN3 yielded the benthic foraminifera *Marginulina mexicana* var. B and *M. asperuliformis.* Thornton (1986, pers. commun.) assigned these species to the early Eocene Benthic Zone "C" (lower "Capay Stage") of Laiming (1940a, 1940b, 1943).

The upper 400 m of the Juncal Formation and the overlying Matilija Sandstone? delta-front deposits contain macrofossils that have been reported (Hanna, 1927; Turner, 1938; Vokes, 1939; Merriam, 1941; Weaver, 1943; Givens, 1974; Givens and Kennedy, 1979; Saul, 1983; Squires, 1984) elsewhere on the West Coast only from the "Domengine Stage." These taxa are *Ancilla* (*Spirancilla*) *gabbi, Conus caleocius, Proximitra? cretacea, ?Pyramidella preblei, Turritella uvasana applinae, Callista* (*Macrocallista*) *domenginica, Gari texta,* and *Spisula merriami.*

Additional evidence for a "Domengine" age for this part of the section is the joint occurrence of taxa whose stratigraphic ranges elsewhere on the West Coast overlap only within the "Domengine Stage." *Dentalium stentor, Glycymeris* (*Glycymeris*) *rosecanyonensis, Crassatella uvasana,* and *Glyptoactis* (*Glyptoactis*) *domenginica* have their lowest stratigraphic occurrence in the "Domengine Stage" (Turner, 1938; Vokes, 1939; Verastegui, 1953; Givens, 1974; Givens and Kennedy, 1979; Squires, 1984). *Rotularia* (*Rotularia*) *tejonense, Ectinochilus* (*Macilentos*) *macilentus,* and *Fusiturricula* (*Crenaturricula*) *crenatospira* have their highest stratigraphic occurrence in the "Domengine Stage" (Vokes, 1939; Givens, 1974; Givens and Kennedy, 1979; Squires, 1984).

A microfossil sample (CN4) from siltstone in the uppermost part of the transition-zone deposits of the Juncal Formation, approximately 800 m above the base of the formation (see "Localities" and Fig. 133, for geographic and

relative stratigraphic positions) yielded the following poorly preserved (overgrown) and rare calcareous nannofossils: *Chiphragmalithus acanthodes, Coccolithus formosus, Helicosphaera seminulum, Markalius astroporus,* and *Teticulofenestra* sp. Filewicz (1986, pers. commun.) assigned this microfauna to the late early Eocene probable *Discoaster lodoensis* (CP11) Zone of Okada and Bukry (1980).

The tidal-flat deposits (including those that interfinger with the braided-river deposits) contain only one molluscan species that is age diagnostic. This species is *Ostrea stewarti,* and prior to its discovery in the Whitaker Peak section it had been reported (Hanna, 1927) only from its type locality in the Ardath Shale ("Domengine Stage") near San Diego, California. *Ostrea stewarti* may also be present in the "Transition"-age *Ectinochilus supraplicatus* fauna in the Pine Mountain area, California, in strata lithologically similar to the tidal-flat deposits in the Whitaker Peak area (Givens, 1986, pers. eommun.).

Although the tidal-flat deposits of the Matilija Sandstone? in the Whitaker Peak area cannot be as confidently dated as the underlying strata, a "Domengine" age is used in this report. With future work, the tidal-flat deposits may prove to be partially "Transition" in age.

The molluscan assemblage in the upper 400 m of the Juncal Formation and the overlying Matilija Sandstone? delta-front and tidal-flat deposits is herein referred to as the *Turritella uvasana applinae* fauna (Fig. 3). This name is chosen because this taxon is both confined to and fairly common in most of the strata.

Three microfossil samples from fine-grained deposits in the lower, middle, and upper parts of the tidal-flat deposits were analyzed for calcareous nannofossils, as well as for planktonic and benthic foraminifera, but were barren (Filewicz, 1986, pers. commun.; Thornton, 1986, pers. commun.).

No fossils were found in the braided-river deposits, but a "Domengine" age is tentatively assigned because the deposits interfinger with the "Domengine"-age tidal-flat deposits (Fig. 3).

CORRELATION

The silstone unit in the lower part of the Eocene section in the Whitaker Peak area is most similar to the Juncal Formation in terms of stratal position, lithology, age, and paleoenvironments. The type section of the Juncal is just east of Agua Caliente Canyon in the Santa Ynez Range, north of Santa Barbara, California (Page, Marks, and Walker, 1951).

The base of the Juncal Formation at the type section is marked by an unconformity associated with a major transgressive-marine event that affected the basin of deposition; namely, the Eocene Santa Ynez basin (Page, Marks, and Walker, 1951; van de Kamp et al., 1974). This basin was a north-trending, elongate trough that was rotated 90° during the Neogene to its current west-trending position (Nilsen and Mckee, 1979; Link and Welton, 1982; Luyendyk, 1986). The lower member of the Juncal Formation consists of few meters of mollusc-bearing and discocyclinid-bearing lenticular, nearshore sandstone overlain by 266 m of neritic zone brown silty shale with a high content of carbonized plant fragments (Page, Marks, and Walker, 1951; Dibblee, 1966). The second member consists of 292 m of shale with some sandstone. The third and uppermost member of the Juncal Formation at the type section consists of 488 m of shale with some sandstone (Dibblee, 1966). Most of the Juncal Formation in the vicinity of the type section represents deep-water turbidite deposits (van de Kamp et al., 1974).

Page, Marks, and Walker (1951) assigned the lower part of their Juncal Formation to the "Capay Stage," based on macrofossils and foraminifera. The middle member was regarded (Page, Marks, and Walker, 1951; Dibblee, 1966) as middle Eocene in age, based on stratigraphic position.

The type Juncal and the siltstone unit in the Whitaker Peak area correlate well in terms of an unconformity at the base, overall silty aspect of the strata, age, and shallow-marine basal part of section overlain by deeper water turbidite deposits. Also, the Matilija Sandstone overlies the Juncal Formation at the type section of the Juncal, and the Matilija Sandstone? (or, at least, a coeval lateral equivalent) overlies the siltstone unit in the Whitaker Peak area. Based on these similarities, it is concluded that this siltstone unit is assignable to the Juncal Formation. In addition, the following fossils occur in both areas: *Pseudophragmina* (*Pseudophragmina*), *Rotularia* (*Rotularia*) *tejonense, Pachycrommium clarki, Fimbria* [=*Corbis*], and *Plicatula.* The similarity in fossils is even stronger when one considers that Eocene *Plicatula* and *Fimbria* have not been found anywhere else on the West Coast except in these two areas.

The Whitaker Peak area is 74 km (46 mi.) east of the type section of the Juncal Formation. Such a distance is not unusual in terms of lateral extent for the Juncal Formation. According to Dibblee (1966) and Dickinson (1969), south of its type section, the Juncal Formation crops out continuously for a distance of 81 km (50 mi.) between the Santa Barbara area and Devils Heart Peak, 5 km (3 mi.) southeast of Sespe Hot Springs, Pine Mountain area. The Juncal exposures in the Devils Heart Peak area are 14.5 km (9 mi.) due west of Piru Creek, Whitaker Peak area.

The presence of the Juncal Formation in the Whitaker Peak area dictates that the Santa Ynez basin extended into this area. How much farther east it extended beyond the Whitaker Peak area is not known because of probable truncation by the San Gabriel fault which lies 2.5 km (1.5 mi.) east of the Whitaker Peak area.

The sandstone unit in the upper part of the Eocene section in the Whitaker Peak area is most similar to the Matilija Sandstone in terms of stratal position, lithology, age, and paleoenvironment. The type section of the Matilija Sandstone is near Matilija Springs in the Santa Ynez Range, north of Ojai, California (Kerr and Schenck, 1928).

The Matilija Sandstone at the type section is 800 m thick and is transitional with the underlying Juncal Formation. The Matilija Sandstone records a major regressive event in the Santa Ynez basin in which deep-sea sand-fan turbidites were deposited and subsequently covered by shallow-marine and coastal deposits (van de Kamp et al., 1974; Link and

Welton, 1982). Link and Welton (1982) reported a middle Eocene (Ulatisian) age for at least the lower half of the Matilija Sandstone, based on benthic foraminifera, and a middle Eocene (P11 and P12 zones) age for the overlying Cozy Dell Formation, based on benthic and planktonic foraminifera (Fig. 5).

The type Matilija Sandstone and the sandstone unit in the Whitaker Peak area correlate well in terms of the transitional nature with the underlying Juncal Formation, sandstone lithology, age, and shallow-marine/coastal deposits associated with a regression of the sea. The deep-sea sand-fan turbidites, however, are lacking in the lower part of the sandstone unit in the Whitaker Peak area. Baed on the similarities, it is concluded that the sandstone unit in the upper part of the Whitaker Peak area is tentatively assignable to the Matilija Sandstone.

The Whitaker Peak area is 55 km (34 mi.) east of the type section of the Matilija Sandstone. According to Link and Welton (1982), the Matilija Sandstone is fairly extensive and forms prominent strike ridges in the Santa Ynez Mountains for more than 77 km (48 mi.). The basin of deposition may have been at least 200 km (125 mi.) long (Link and Welton, 1982). According to Dickinson (1969), the Matilija Sandstone can be traced from its type section area to the Sespe Creek area immediately north of the town of Fillmore, California, which is 19 km (12 mi.) southwest of Bluepoint Campground (Fig. 1), Whitaker Peak area. Eschner (1969) used the name "Topatopa Sandstone" for the Matilija Sandstone in the vicinity of Fillmore. According to Wilmarth (1938), however, the name "Topatopa Sandstone" was rejected for use in the classification of the United States Geological Survey.

The Eocene strata in the Whitaker Peak area are strikingly similar lithologically, paleontologically, and paleoenvironmentally to the lower two-thirds of the Eocene section in the Pine Mountain area, especially near Sespe Hot Springs, 26 km (16 mi.) to the west of the Whitaker Peak area. Givens (1974) assigned the bulk of the Eocene section in the Pine Mountain area to the Juncal Formation. His assignment was based on lithologic and stratigraphic position similarities to the Juncal Formation elsewhere in the Transverse Ranges.

As with the Whitaker Peak area, the base of the Juncal Formation in the Pine Mountain area is marked by an unconformity on pre-Tertiary granitic rocks, and a thin, basal conglomerate bed of locally derived detritus is in depositional contact with the basement. In the lower 150 m of the overlying inner sublittoral mudstone with minor sandstone, there are molluscan assemblages (Jestes, 1963; Givens, 1974) that Givens (1974) assigned to his *Turritella uvasana infera* fauna ("Capay Stage") (Fig. 5). Many of the fossils that characterize his fauna are conspecific with those in the *Turritella uvasana* fauna of the Whitaker Peak area. The most notable taxa are *Pseudophragmina* (*Pseudophragmina*), *Clavilithus tabulatus, Turritella andersoni, Turritella uvasana infera, Velates perversus, Miltha packi, Ostrea haleyi, Pholadomya* (*Bucardiomya*) *givensi,* and *Venericardia* (*Pacificor*) *hornii lutmani.* Jestes (1963) also reported *Campanile* sp. and *Lyrischapa* sp. [=*Volutocristata*] from the lower part of the mudstone in the Pine Mountain area, and these taxa help characterize the lower part of the Juncal Formation in the Whitaker Peak area. Jestes (1963) and Givens (1974) reported that *Velates perversus* is locally very abundant in the Pine Mountain area, a situation that occurs also in the Whitaker Peak area.

Upsection in the Pine Mountain area, there is a thick interval of deltaic, fossiliferous medium to coarse sandstone that, like the comparable Matilija Sandstone? in the Whitaker Peak area, is extensively bioturbated and in the upper part contains red-and-green siltstone beds. Givens (1974) considered this sandstone in the Pine Mountain area to be part of the Juncal Formation and assigned the molluscs in the sandstone to his *Turritella uvasana applinae* fauna ("Domengine Stage") (Fig. 5). Many of the fossils that characterize his fauna are conspecific with those in the *Turritella uvasana applinae* fauna of the Matilija Sandstone? in the Whitaker Peak area. The most notable species are *Pseudoperissolax blakei praeblakei, Proximitra? cretacea, Turritella uvasana applinae, Glycymeris* (*Glycymeris*) *rosecanyonensis,* and *Pitar* (*Lamelliconcha*) *joaquinensis.*

Filewicz (1986, pers. commun., see "Age" section of this present report) studied the calcareous nannofossil assemblages of the Juncal Formation, Whitaker Peak area, and Filewicz and Hill (1983) also studied the calcareous nannofossil assemblages of the Llajas Formation, Simi Valley, California. Filewicz (1986, pers. commun.) concluded that 1) the calcareous nannofossils from the lower 150 m of the Juncal Formation in the Whitaker Peak area are older than those recovered from the "Capay Stage" portion of the Llajas Formation (100 m above the base), and 2) at 150 m above the base of the Juncal Formation in the Whitaker Peak area (i.e., microfossil locality CN3), the calcareous nannofossils are age equivalent or slightly older than the "Capay Stage" portion of the Llajas Formation (Fig. 5).

The *Turritella uvasana applinae* fauna of the Whitaker Peak area is time correlative to the remaining portion ("Domengine Stage") of the Llajas Formation (Squires, 1984).

Suggested correlations of the Whitaker Peak Eocene section with additional representative Eocene sections on the West Coast are shown in Figure 5. According to Miles (1981), the early Eocene Lookingglass Formation in southwestern Oregon (Fig. 5, column 7) includes the often-quoted Glide section macrofauna that was illustrated and described by Turner (1938).

PALEOCLIMATE

During the Paleocene and Eocene, the world climate was relatively warm and equable although there were important cool intervals in the middle Paleocene and middle Eocene (Kennett, 1982; Siesser, 1984). During the Paleocene and Eocene, mixed conifer-hardwood and deciduous-hardwood forests blanketed the arctic region (Axelrod, 1984). Eocene laterites, indicative of very warm, very wet environments also have been found on the Siberian platform (Parrish, Ziegler, and Scotese, 1982). Early Eocene shallow-marine faunas from Ellesmere Island (79°30′N), Alaska (72°N), and Spits-

bergen trough (78°N) indicate that temperate conditions prevailed at that time in the high Arctic (Marincovich and Zinsmeister, 1985). West Coast Eocene macrofaunas have long been assigned to tropical or subtropical environments (Arnold, 1909; Dickerson, 1917a; Smith, 1919; Clark and Vokes, 1936; Berthiaume, 1938; Vokes, 1940; Durham, 1950; Squires, 1984).

A worldwide late Paleocene warming trend culminated in a period of peak warming during the early Eocene (Haq et al., 1977; Kennett, 1982). According to Frakes (1979) and Haq (1981), the early Eocene was the warmest interval of the Cenozoic. The Arctic waters were essentially isolated, and the circum-Antarctic current had not yet formed. There was little mixing of the cooler polar waters with the warmer ocean waters elsewhere in the world, hence, the equator-to-pole gradient was low (Stanley, 1986). Mild climates were the norm, there were no polar ice caps, and the mean annual temperature was approximately 21°C (70°F) (Berggren and Hollister, 1974).

During the early Eocene, tropical conditions existed as far north as southern England (Berggren and Hollister, 1974; Plaziat, 1981). According to Berggren and Hollister (1974), who corrected for continental drift, the Eocene marine tropical zone extended to about latitude 50°N on the Pacific Coast of North America (Eocene paleolatitude of about 45°N) and to about latitude 60°N on the west coast of Europe (Eocene paleolatitude of about 50°N). According to Zinsmeister (1985), temperate climatic conditions were present as far south as Seymour Island, Antarctic Peninsula (68°18′S) during the early Tertiary.

The equable Eocene conditions ceased in late Eocene through early Oligocene time with the appearance of a worldwide cooling trend. This cooling was associated with the development of circum-Antarctic circulation, as well as with flowage of Arctic Ocean waters into the Atlantic. The cooling caused the tropical zone to retreat toward the equator as the equator-to-pole temperature gradients increased (Kennett et al., 1975; Kennett, 1982; Zinsmeister, 1982; Stanley, 1986).

As previously discussed, the marine-mollusc-bearing portion of the Juncal Formation in the Whitaker Peak area was deposited during the early Eocene and shortly thereafter. The deposition coincided with the peak warm interval of the Cenozoic, and the macrofossil evidence strongly supports the presence of tropical/subtropical waters in this area at that time.

The *Turritella uvasana infera* fauna (early Eocene "Capay Stage" of the Juncal Formation in the Whitaker Peak area contains the following molluscs which have been widely recognized (Gardner, 1912, 1931; Vokes, 1935; Clark and Vokes, 1936; Gardner and Bowles, 1939; Wrigley, 1942; Palmer and Richards, 1954; Palmers, 1957, 1967; Adegoke, 1972, 1977; Squires, 1985, 1986) as positive indicators of Eocene Old World Tethyan-affinity paleoenvironmental conditions (i.e., warm waters): *Campanile, Gisortia, Lyria, Velates perversus, Fimbria,* and *Venericardia* (*Pacificor*). The *T. uvasana infera* fauna also contains the following Old World Tethyan gastropod genera that Davies (1975) and Squires (1986) reported as originating in the Pakistan part of the ancient Tethys Sea (i.e., the Tethys Sea extended from Indonesia through the present Mediterranean region): *Apiotoma, Athleta, Clavilithes, Cryptoconus, Eopleurotoma, Pachycrommium, Pleurofusia, Strepsidura,* and *Streptochetus.* In addition, the *T. uvasana infera* fauna also contains the following extant molluscs whose modern forms are most frequently found today (Nicol, 1950; Cox and Hertlein, 1969; Jackson, 1970; Kennedy, Morris, and Taylor, 1970; Hertlein and Grant, 1972; Squires, 1984) in tropical/subtropical waters: *Architectonica, Calyptraea, Conus, Fusiturricula, Olivella, Phalium* (*Semicassis*), *Pseudoliva, Turritella, Barbatia, Brachidontes, Callista* (*Costacallista*), *Chama, Corbula* (*Caryocorbula*), *Gari, Glycymeris, Miltha, Nemocardium, Pitar* (*Lamelliconcha*), *Plicatula,* and *Solena.* The taxa *Fusiturricula, Pseudoliva, Pitar* (*Lamelliconcha*), and *Solena* are particularly significant as they are confined to tropical waters only.

A few specimens of the hermatypic colonial scleractinian coral *Astrocoenia* also were found in the *T. uvasana infera* fauna. Today, this coral genus lives only in the West Indies and is a reef dweller in shallow tropical seas (Durham, 1942a). According to Durham (1942a), this coral indicates tropical rather than subtropical waters.

Several of the extinct genera of the *T. uvasana infera* fauna, including *Pseudophragmina* (*Pseudophragmina*) (i.e., a discocyclinid foraminifera), *Chedevillia, Ectinochilus* [=*Rimella*], *Eocernina, Ficopsis,* and *Lyrischapa,* have been found to be tropical to subtropical in their distribution or have modern analogues that live in such waters (Durham, 1950; Givens, 1974, 1979).

Other mollusc-bearing strata of "Capay" age on the West Coast are also tropical to subtropical in their paleoenvironment (Durham, 1950). Such strata have been found as far north as the southern end of Vancouver Island. In addition to the molluscs, reef corals, discocyclinids, brachiopods, and coralline algae are present.

A very small percentage of the *T. uvasana infera* fauna in the Whitaker Peak area has a cooler water aspect to it. *Acanthocardia* is most commonly found in warm temperate seas today. *Neverita* (*Glossaulax*), the closest relative to the Paleogene *Neverita* (*Neverita*) *globosa* (Givens and Kennedy, 1976; Marincovich, 1977), occurs mainly in temperate waters but also ranges into the tropical Panamic province (Marincovich, 1977). Although *Pholadomya* (*Bucardiomya*) is extinct, *Pholadomya* s.s. is extant. According to Zinsmeister (1986, pers. commun.), *Pholadomya* s.s. is known only from a single specimen from the deep waters of the Caribbean, and although several *Pholadomya*-like taxa occur in Antarctic waters today they are not *Pholadomya* s.s.

The *Turritella uvasana applinae* fauna of the late early through early middle Eocene ("Domengine Stage") Matilija Sandstone? in the Whitaker Peak area contains only two Tethyan-affinity molluscs: *Pachycrommium* and *Pleurofusia.* It contains, nevertheless, the following extant molluscs whose modern forms are most frequently found today (Hertlein and Grant, 1972; Squires, 1984) in tropical/subtropical waters: *Ancilla, Calyptraea, Conus, Fusiturricula, Nerita, Olivella, Phalium* (*Semicassis*), *Polinices* (*Euspira*), *Sinum, Turritella, Brachidontes, Callista* (*Costacallista*), *Corbula* (*Caryocor-*

bula), *Gari, Glycymeris, Ostrea, Nemocardium,* and *Pitar* (*Lamelliconcha*). The taxa *Ancilla, Fusiturricula,* and *Pitar* (*Lamelliconcha*) are particularly significant as they are confined to tropical waters only.

Several of the extinct genera of the *T. uvasana applinae* fauna, including *Ectinochilus* [=*Rimella*], *Eocernina, Ficopsis,* and *Crassatella,* have been found to be tropical to subtropical in their distribution or have modern analogues that live in such waters (Durham, 1950; Givens, 1974).

As with the *T. uvasana infera* fauna, a very small percentage of the *T. uvasana applinae* fauna in the Whitaker Peak area has a cooler water aspect to it. *Acanthocardia* and *Acila* (*Truncacila*) are commonly found in warm temperate seas today, but the latter can range into cold waters (Schenck, 1936; Squires, 1984). *Spisula* is commonly found today in temperate waters (Abbott and Dance, 1982).

PALEOBIOGEOGRAPHY

The Eocene world ocean was influenced by the circulation patterns established during the Cretaceous and Paleocene. The Tethys Current dominated the tropical circulation and flowed westward through the Tethys Seaway and Central America to form a circumglobal tropical current, contributing to a widespread dispersal of marine biota (Haq, 1981) and a unification of faunas (Davies, 1975).

The exact position of where the portal was between the Atlantic and Pacific oceans during the early and middle Eocene is not known. Clark and Vokes (1936) suggested that it was in Central America. Gardner and Bowles (1934) and Maldonado-Koerdell (1950) suggested that during the Eocene there was a portal in the Isthmus of Tehuantepec region, southern Mexico. They based their suggestion on the observation that Eocene molluscs at the Mexican locality showed affinities to California molluscs of similar age ("Domengine Stage"). Durham, Arellano, and Peck (1955), after a larger study of this Mexican fauna, concluded that it more closely resembles Caribbean–Gulf of Mexico faunas rather than California faunas, and they further concluded that no interoceanic seaway existed in the Isthmus of Tehuantepec during the Cenozoic. They also proposed, but with no supporting evidence, that the seaway may have been through the northwestern Colombia or Panamic areas.

Seas did cover northwestern Colombia in the Eocene, but if there was any interchange between Atlantic and Pacific waters in that area, the effect on Californian molluscan faunas seems to have been minimal. Clark and Durham (1946) concluded this after a detailed study of Eocene molluscs in northwest Colombia. They reported that the basins of deposition in northwest Colombia and Peru were fairly well isolated in the early and middle Eocene and had very little if any connection with the Caribbean until the late Eocene.

Seas did cover portions of Panama in the early and middle Eocene (Weyl, 1980). A seaway connection is possible, but much more stratigraphic and paleontologic work are needed to confirm this possibility.

Another promising possibility of where the seaway was is Costa Rica. In the Cordillera de Guanacoste region in northern Costa Rica (Pacific side), there is a late Paleocene through Eocene section consisting of shallow-marine reef limestones (Bara Honda Formation) and reef limestones intercalated with tuffaceous arenites (Brito Formation). The Brito Formation continues into southwest Nicaragua (Weyl, 1980). Unfortunately, the same sequence cannot be found on the Atlantic side of Costa Rica, but future paleontologic work in the Cordillera de Guanacoste region may prove the presence of an early through middle Eocene seaway there. As will be discussed below, there are strikingly similar molluscan species (or, in one case, the same species) in the California Eocene and Anglo-Paris Basin Eocene deposits. What is needed is to find these molluscs in the Central American region.

Clark and Vokes (1936), Vokes (1939), Givens and Kennedy (1976), Givens (1978), and Squires and Advocate (1986) have listed a total of 23 molluscan species from the "Capay" and "Domengine" "stages" of the West Coast that show affinities with molluscs from the corresponding Ypresian and Lutetian stages of the Anglo-Paris Basin Eocene. Nine of these species are present in the *Turritella uvasana infera* fauna of the Whitaker Peak area; namely, *Chedevillia saltonensis, Clavilithes tabulatus, Cryptochorda* (*Cryptochorda*) *californica, Cryptoconus cooperi, Fusiturricula* (*Crenaturricula*) *crenatospira, Gisortia clarki, Lyria andersoni,* and *Turritella andersoni.* Nine additional molluscan species from the *T. uvasana infera* fauna of the Whitaker Peak area that show very close affinities with certain Paris Basin Eocene species are the following: *Apiotoma californiana* new species, *Benoistia cantonensis* new species, *Eopleurotoma whitaker-peakensis* new species, *Hemitoma* (*Montfortia*) *cantonensis* new species, *Monodonta* (*Incisilabium*?) *piruensis* new species, ?*Pseudovertagus* (*Pseudoaluco*) sp., *Streptochetus californiana* new species, *Chama piruensis* new species, and *Plicatula juncalensis* new species. See the "Systematic Paleontology" section of this present report for the names and comparisons of the corresponding Paris Basin species.

Two macrofossil species from the *T. uvasana infera* fauna of the Whitaker Peak area that show very close affinities with certain West Indies Eocene species are *Fimbria* new species? and the colonial coral *Astrocoenia* new species?. *Fimbria* new species? also is similar to a southeastern United States Eocene species. Two additional molluscan species from the *T. uvasana infera* fauna that also show very close affinities with certain southeastern United States late Paleocene and Eocene species are *Athleta roddai* new species and *Plicatula juncalensis* new species. See the "Systematic Paleontology" section for the names and comparisons of the corresponding southeastern United States forms.

The distribution of the discocyclinid foraminifera *Pseudophragmina* (*Pseudophragmina*) *clarki* is additional evidence of the inter-oceanic seaway. This species has been found in Florida, Mexico, Cuba, Trinidad, and Jamaica, as well as in Peru through southwestern Oregon (Cole, 1958, 1969; Cole and Applin, 1964; Blondeau and Brabb, 1983; Squires, 1984). On the West Coast, it ranges from the "Capay" through the "Domengine" "stages" (Squires, 1984). Specimens of *Pseudophragmina* (*Pseudophragmina*) occur in the lower portion of the transgressive-phase transition-zone

deposits of the Juncal Formation in the Whitaker Peak area, but preservation is too poor to allow specific identification.

The most important molluscan species used as evidence of a seaway connection in the tropical Central American region is the neritid gastropod *Velates perversus.* It is predominantly Tethyan in its distribution and has been found in southern and central California, as well as in Pakistan (its homeland), India, Burma, Tibet, Iraq, Iran, the Mediterranean region, Madagascar, Sudan, Nigeria, southern France, the Paris Basin, Hungary, Bavaria, Switzerland, Florida, Jamaica, and possibly Panama (Vokes, 1935; Clark and Vokes, 1936; Joleaud, 1939; Eames, 1952; Palmer, 1967; Davies, 1975; Squires, 1984, 1986; Woods and Saul, 1986). *Velates perversus* is locally very common in the *T. uvasana infera* fauna of the Whitaker Peak area. Elsewhere in California it is also of "Capay" age, except in the Avenal Sandstone occurrence near Coalinga, central California, where it is of lowermost "Domengine" age (Vokes, 1935). This species made its first appearance in the Upper Ranikot beds, Pakistan (Davies, 1975). Aceording to Hasson (1985), these strata are assignable to an early Eocene age.

Accompanying the arrival of *V. perversus* into Californian waters were additional Old World Tethyan gastropods; namely, *Athleta, Clavilithes, Eopleurotoma, Pachycrommium,* and *Streptochetus* (Squires, 1986), as well as *Conus* and *Phalium* (*Semicassis*). Most originated during the early Eocene in the ancient equatorial Tethys Sea in southern Pakistan, west of Hyderābād, and have been found in the early Eocene Upper Ranikot beds (Cossmann and Pissarro, 1909; Davies, 1975; Hasson, 1985).

The striking similarity between *Athleta roddai* new species from the Whitaker Peak area and *A. tuomeyi* from early Eocene strata in the Atlantic and Gulf coastal plains of southeastern United States and possibly Chiapas, Mexico, indicates that although *Athleta* may have originated in Pakistan, a Caribbean-influenced *Athleta* eventually reached California.

Adegoke (1972, 1977) reported two species of *Clavilithes* from the Ewekoro Formation (late Paleocene) of southwestern Nigeria. Evidently, *Clavilithes* originated in the Tethys Sea during the late Paleocene rather than early Eocene.

Strepsidura ficus? from the lower Claiborne Group in Texas bears a remarkable resemblance to the California species according to Palmer and Brann (1966). These strata are early to middle Eocene in age (Siesser, Fitzgerald, and Kronman, 1985). Unfortunately, the Texas specimens have been lost and only drawings are available. If the specific identification is correct, then *S. ficus* is the only species known to be common between the Mississippi and California areas (Palmer and Brann, 1966). Davies (1975) reported that *Strepsidura* originated in Pakistan in the Upper Ranikot beds, now regarded as early Eocene in age (Hasson, 1985). Interestingly, however, Palmer and Brann (1966) reported the occurrence of *Strepsidura contorea* from the uppermost Porters Creek Formation (upper Midway Group) of Alabama. These strata are of early Paleocene age according to Siesser, Fitzgerald, and Kronman (1985). Adegoke (1977) reported the occurrence of *Strepsidura kerstingi* from the Ewekoro Formation (late Paleocene) of southwestern Nigeria. Evidently, *Strepsidura* originated in the Tethys Sea region during the early Paleocene rather than early Eocene but just has not been found in the Tethyan-region Paleocene section. Stanton (1896) reported *Strepsidura pacheocoensis* from Paleocene ("Martinez Stage") strata in northern California (Keen and Bentson, 1944).

Arrival of the Tethyan gastropods in California during the early Eocene was coincident with a major global sea-level rise (TE1.2 cycle of Vail and Hardenbol, 1979) (Fig. 4). This sea-level rise was also coincident with the transgressive phase of deposition of the lower part of the Juncal Formation in the Santa Ynez basin (i.e., includes the Whitaker Peak area). Most of these Tethyan gastropods were fairly widespread throughout California but went no farther north than California, except for *Pachycrommium* which went as far north as Washington. The *Turritella uvasana infera* fauna in the Whitaker Peak area, however, is the only one in which they all occur together. Most of these genera emigrated southward out of the California area by the end of early middle Eocene time, except for *Pachycrommium* and *Strepsidura,* which left by the end of the Eocene (Squires, 1986). West Coast Oligocene reports of *Strepsidura* (Keen and Bentson, 1944) are incorrect because *S. californica* actually belongs in *Siphonalia* (Clark and Woodford, 1927; Ruth, 1942), and *S. lincolnensis lorenzana* does not belong in *Strepsidura* (Clark and Woodford, 1927).

Additional Old World Tethyan-affinity molluscan genera entered Californian waters during the early Eocene. These genera are *Amaurellina, Benoistia, Crepidula, Ectinochilus, Hemitoma* (*Montfortia*), *Lyrischapa, Monodonta, Paraseraphs,* ?*Pseudovertagus* (*Pseudoaluco*), ?*Pyramidella* [=*Syrnola*], *Sinum, Barbatia, Chama, Callista* (*Costacallista*), and *Tellina* (*Macaliopsis*). None of these genera has been reported from West Coast strata older than the "Capay Stage." Paleobiogeographic details concerning these genera are limited, and their point(s) of origin are imperfectly known. Most can be traced back, at least, to the Paris Basin (Cossmann and Pissarro, 1910–1913; Wenz, 1940; Kennedy, Morris, and Taylor, 1970; Bernard, 1976; Houbrick, 1978). *Lyrischapa* may have had a Caribbean origin (Givens, 1979).

Four other genera might possibly be added to the above list, but there are imprecise or nonexistent locality descriptions concerning their earliest occurrence on the West Coast. These genera are the calcareous annelid tube *Rotularia* (*Rotularia*), and the molluscs *Chedevillia, Cryptochorda,* and *Fusiturricula.*

Fimbria was reintroduced to the West Coast during the early Eocene "Capay" time after having been present in southern California in the Late Cretaceous (Dawson, 1978). *Glyptoactis* (*Glyptoactis*) originated on the West Coast during "Capay" time, and *Proximitra*? possibly originated on the West Coast during "Domengine" time (Squires, 1984). *Hilgardia,* a North American bivalve, is known from older Eocene strata on the West Coast than on the East Coast (Palmer and Brann, 1965). *Glycymeris* (*Claibornicardia*), a European and North American bivalve, is also known from older Eocene strata on the West Coast than on the East Coast

(Stenzel, Krause, and Twining, 1957). With future work both of these taxa will probably be found in early Eocene strata in the southeastern United States.

The majority of the macrofauna genera of the Juncal Formation in the Whitaker Peak area were already present on the West Coast by "Capay" time. Several species, in addition, were carryovers from earlier times. *Calyptraea diegoana, Crommium pinyonensis, Polinices* (*Euspira*) *nuciformis, Pseudoperissolax blakei praeblakei, Olivella mathewsonii, Scaphander* (*Mirascapha*) *costatus, Surculites mathewsonii, Acila* (*Truncacila*) *decisa,* and *Nemocardium linteum* have been reported from late Paleocene "Martinez Stage" strata on the West Coast (Nelson, 1925; Weaver, 1953; Smith, 1975; Zinsmeister, 1974, 1983a; Marincovich, 1977). *Cryptoconus cooperi, Galeodea* (*Gomphopages*) *meganosensis, Neverita* (*Neverita*) *globosa, Turritella uvasana infera, Brachidontes* (*Brachidontes*) *cowlitzensis,* and possibly *Turritella andersoni* have been reported from late Paleocene–early Eocene "Meganos Stage" strata on the West Coast (Clark and Woodford, 1927; Clark, 1929; Givens, 1974; Marincovich, 1977; Saul, 1983).

The Tethyan molluscs *Apiotoma, Campanile, Gisortia, Lyria, Pleurofusia,* and *Venericardia* (*Pacificor*) also occur in the early Eocene portion ("Capay Stage") of the Juncal Formation in the Whitaker Peak area, but they arrived in California during the Paleocene (Hanna and Hertlein, 1939; Smith, 1975; Saul, 1983; Zinsmeister, 1974, 1983a).

In summary, there was a considerable influx of molluscs and other marine organisms into western North America during early Eocene ("Capay") time. About eight Old World Tethyan genera (and one species) and about 19 other Old World Tethyan-affinity genera of molluscs immigrated into the West Coast region by way of southern Central America. Many of the species of these genera, as well as some of the species of genera already present on the West Coast, show close affinities with Anglo-Paris Basin species. Only a few of the genera that arrived on the West Coast in "Capay" time show Caribbean influences. A few taxa originated on the West Coast during this time, one genus was reintroduced, and several species were Paleocene relicts.

This "Capay" influx coincided with a global sea-level rise and possibly the warmest time of the Cenozoic. This pulse of immigration was probably similar to an earlier one that took place on the West Coast during late Paleocene ("Martinez Stage") time, according to Zinsmeister (1983a). Another pulse of immigration took place during late early through early middle Eocene ("Domengine Stage") (Squires, 1984), but it was not as extensive as the earlier two.

METHODS AND SYSTEMATIC MATERIALS

From 1974 through 1975, the Matilija Sandstone? was geologically mapped by the author during the course of teaching an advanced field-geology class of California State University, Northridge. During that time, about 300 specimens of macrofossils were collected from 10 localities. These collections formed the basis for a preliminary faunal list (Squires, 1977) of the sparsely fossiliferous Matilija Sandstone?. From 1984 through 1985, the Juncal Formation was geologically mapped by the author, and an intensive and meticulous search of the formation was undertaken for macrofossils. About 2000 specimens were obtained from 60 localities. In the course of the paleontologic study of the Juncal Formation, the macrofauna of the Matilija Sandstone? was restudied and many refinements were made.

Systematic arrangement of the generic and higher taxonomic categories follows that of Wells (1956) for the coral; Howell (1962) for the calcareous annelid tube; Ludbrook (1960) for the scaphopod; Cox et al. (1969) and Vokes (1980) for the bivalves; and Fischer (1966) for the echinoids. The systematic arrangement of Wenz (1938–1944) is followed generally for the gastropods.

The figured specimens, as well as those paratypes that are unfigured, are on deposit in the Natural History Museum of Los Angeles County, Invertebrate Paleontology section. Additional unfigured specimens are on deposit in the Department of Geological Sciences Paleontology collection, California State University, Northridge.

The synonymies are selective. Works that include original figures and/or descriptions are listed. References that add pertinent taxonomic and documentable biostratigraphic information are also included. More complete synonymies of some of the gastropods and bivalves can be found in Stewart (1927, 1930).

Primary type material, molluscan stage range, geographic distribution, local occurrence, and remarks are listed for all the species. Unless otherwise noted, such data are derived from references listed in the synonymies or from new data obtained in the course of this present study. "Primary type material" refers to the holotype, paratype(s), syntypes, lectotypes, or neotype of the senior subjective synonym of each taxon. In the case of homonyms, the junior homonym "primary type material" is listed, and if the new name "primary type material" is different it is listed also. The molluscan stages are for the West Coast, and they are from Clark and Vokes (1936) and Weaver et al. (1944), with refinements made by Givens (1974) and Saul (1983). The stages are provisional, hence the names are placed in quotation marks. The relative age of each stage and correlation with various biostratigraphic zones are shown in Figure 4. Any taxa stage range extensions that are the result of this present study are so mentioned under the "Remarks" for each species. Locality information for all the localities mentioned in this report is given in the "Localities" section.

Letter abbreviations used for catalog and/or locality numbers are:

ANSP: Academy of Natural Sciences of Philadelphia.
CAS: California Academy of Sciences.
CSUN: California State University, Northridge.
MCZ: Museum of Comparative Zoology, Harvard.
LACMIP: Los Angeles County Museum of Natural History, Invertebrate Paleontology section.
SDNHM: San Diego Natural History Museum.
SU: Stanford University (collections now housed at the California Academy of Sciences).

UCMP: University of California Museum of Paleontology (Berkeley).
UCLA: University of California, Los Angeles (collections now housed at the Los Angeles County Museum).
UCR: University of California, Riverside.
UO: University of Oregon.
USGS: United States Geological Survey (Washington, D.C. register).
USNM: United States National Museum of Natural History.
UW: University of Washington.

SYSTEMATICS

Phylum Coelenterata

Subphylum Cnidaria

Class Anthozoa

Subclass Zoantharia

Order Scleractinia

Suborder Astrocoeniina

Family Astrocoeniidae Koby, 1890

Subfamily Astrocoeniinae Koby, 1890

Genus *Astrocoenia* Milne-Edwards and Haime, 1848

Type Species. By monotypy, *Astrea numisma* Defrance, 1826.

Astrocoenia new species? aff. *A. portoricoensis* Vaughan, 1919

Figure 6

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation, CSUN localities 361, 844.

Remarks. Two medium-sized colonies (up to 50 mm height and 80 mm length) were found at locality 844, and one smaller colony (40 mm height and 40 mm length) was found at locality 361. Most of the corallites in the colonies from locality 844 are plugged with hard matrix, but a few are free of the matrix. The colony from locality 361 is a fragment and is badly weathered.

The colonies from locality 844 have an irregular upper surface with short protuberances. The corallites are polygonal shape and have eight (very rarely ten) septa that extend to the styliform collumella, which appears in the bottom of the calice as a tubercle. Inside diameter of the calices is about 1 mm, and the thecal walls are about 0.25 mm thick.

The Whitaker Peak colonies are similar to *Astrocoenia portoricoensis* Vaughan (1919:350–351, pl. 76, figs. 4, 4a; pl. 78, figs. 1, 1a; Frost and Langenheim, 1974:177, 180, pl. 52, figs. 5–7) from Oligocene and lower Miocene strata, Mexico (Chiapas), Puerto Rico, Antigua, and Panama. The Whitaker Peak colonies, however, show no indication of secondary septa between the eight major septa, can have ten major septa, and have slightly smaller calices. These differences are minor and may be due to preservation or growth stage. In *A. portoricoensis,* the secondary septa can be rudimentary, thereby making the two forms even more similar. Better specimens of *Astrocoenia* new species? will be necessary before a possible conspecific determination can be made.

Astrocoenia dilloni Durham (1942a:505, pl. 44, fig. 3) from early Eocene strata, Media Agua Creek, west side of San Joaquin Valley, Kern County, California, is the only other species of this genus known from the West Coast Tertiary. *Astrocoenia* new species? differs from *A. dilloni* in having only eight rather than ten septa with no secondary septa between the major septa. Durham (pers. commun.) examined *A.* new species? from the Whitaker Peak area and concluded that it is not the same as *A. dilloni.*

Phylum Annelida

Class Polychaeta

Order Sabellida

Family Serpulidae Lamarck, 1818

Genus *Rotularia* Defrance, 1827

Type Species. By subsequent designation (Wrigley, 1951), *Rotularia spirulaea* (Lamarck, 1818).

Subgenus *Rotularia* s.s.

Rotularia (*Rotularia*) *tejonense* (Arnold, 1910)

Figures 7, 8

Spiroglyphus? tejonensis Arnold, 1910:51, pl. 4, fig. 18. Dickerson, 1916:pl. 37, figs. 5a–b. Vokes, 1939:162–163, pl. 20, figs. 20–22. Stewart, 1946:pl. 11, fig. 21.
Spiroglyphus tejonensis Arnold. Hanna and Hertlein, 1941: figs. 62-4, 62-20.
?*Tubulostium tejonense* (Arnold). Keen and Bentson, 1944: 195.
Rotularia tejonense (Arnold). Nilsen, 1973:table 1. Squires, 1977: table 1; 1984:15, fig. 5g.

Primary Type Material. USNM holotype 165658, Avenal Formation, USGS locality 4617.

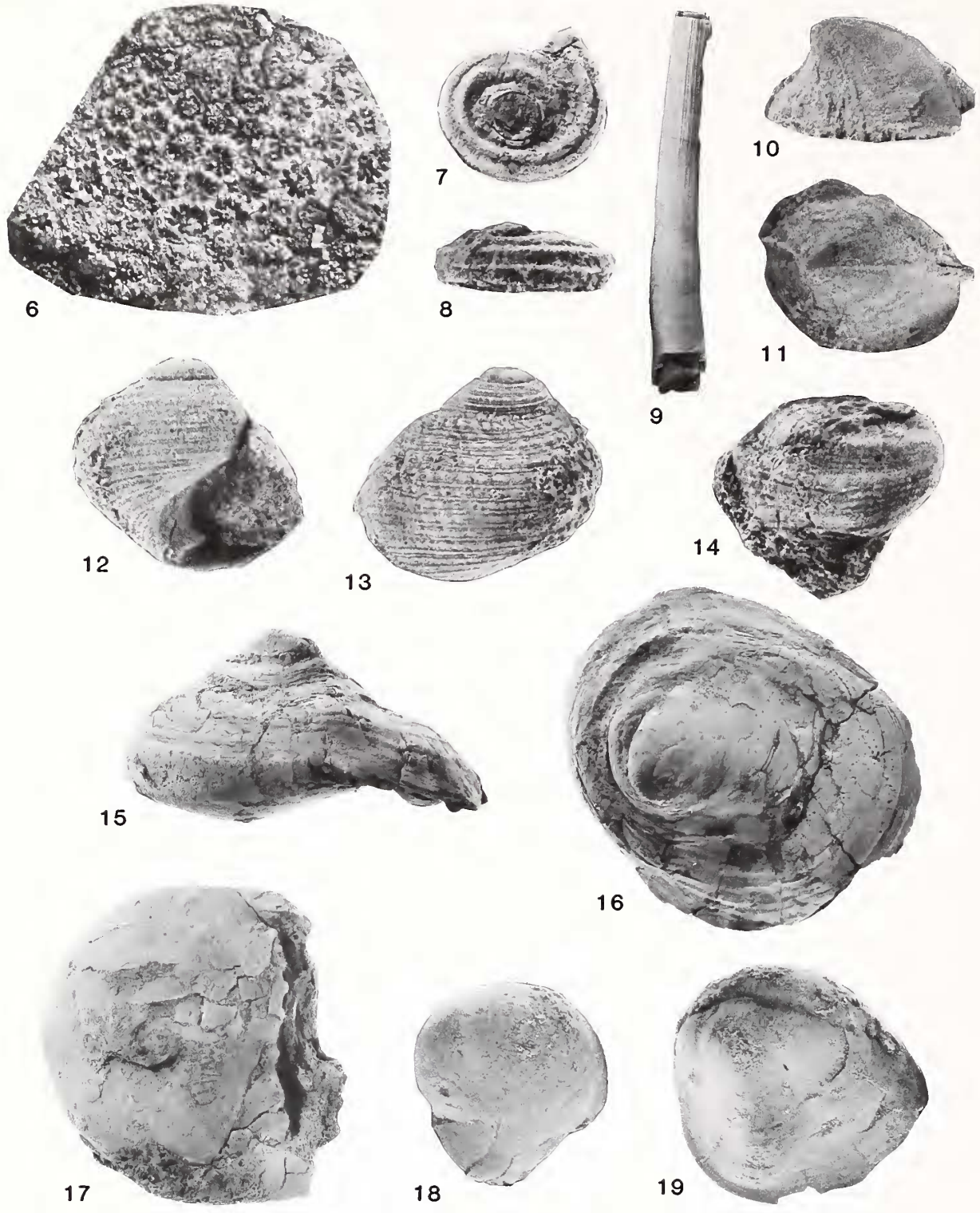
Molluscan Stage Range. "Capay" through "Transition."

Geographic Distribution. Simi Valley, southern California through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 361, 810, 830, 836, 840, 844, 849, 850, 851, 852. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. At all the localities, except 237, 850, and 851, only a few (less than six) specimens were found. At locality 237, 35 specimens were found. At locality 850, nine specimens were found, and at locality 851, 19 specimens were found. Preservation is poor except at locality 237.

This species has a very raised carina adjacent to the suture



Figures 6–19. Whitaker Peak area Eocene colonial coral, calcareous annelid tube, scaphopod, and archaeogastropods. **Figs. 6–9.** Colonial coral, calcareous annelid tube, and a scaphopod. **6.** *Astrocoenia* new species? aff. *A. portoricensis* Vaughan, 1919, dorsal view. ×4, width of field 16 mm, LACMIP hypotype 7436, CSUN loc. 844. **7–8.** *Rotularia* (*Rotularia*) *tejonense* (Arnold, 1910). All parts from CSUN loc. 237. **7.** Umbilical view, ×3, greatest diameter 9.5 mm, LACMIP hypotype 7437. **8.** Side view, ×3, diameter 9.5 mm, LACMIP hypotype 7438. **9.** *Dentalium stentor* Anderson and Hanna, 1925, partial specimen, side view, ×1.9, length 33 mm, LACMIP hypotype 7439, CSUN loc. 219. **Figs. 10–19.** Archaeogastropods. **10–11.** *Hemitoma* (*Montfortia*) *cantonensis* new species. All parts with shell surface eroded, height 6.5

on the dorsal and umbilical portions of the sinistrally coiled tube. The tube also has a tricarinate lateral portion. In cross section, the outline of the tube is like that shown by Hanna and Hertlein (1941, fig. 62-4). Usually the tube is planispiral up to 9 mm in diameter, with uncoiling occurring in the later growth stages, but a few specimens at locality 237 are conispiral in the early growth stage.

Phylum Mollusca

Class Scaphopoda

Family Dentaliidae Gray, 1834

Genus *Dentalium* Linné, 1758

Type Species. By subsequent designation (Montfort, 1810), *Dentalium elephantinum* Linné, 1758.

Dentalium stentor Anderson and Hanna, 1925

Figure 9

Dentalium stentor Anderson and Hanna, 1925:145, pl. 13, fig. 17. Squires, 1984:16, fig. 5h.
Dentalium stentor? Anderson and Hanna. Squires, 1977:table 1.

Primary Type Material. CAS holotype 819, Tejon Formation, CAS locality 792.

Molluscan Stage Range. "Domengine" through "Tejon."

Geographic Distribution. Simi Valley, southern California through southern San Joaquin Valley, south-central California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 237.

Remarks. Except for the figured specimen (Fig. 9), specimens occur as small fragments. The shells show fairly prominent longitudinal ribs alternating with finer ribs. Ribbing is stronger near the apex.

Class Gastropoda

Subclass Prosobranchia

Order Archaeogastropoda

Superfamily Fissurellacea

Family Fissurellidae Fleming, 1822

Subfamily Emarginulinae Gray, 1834

Genus *Hemitoma* Swainson, 1840

Type Species. By original designation, *Patella tricostata* J. Sowerby, 1823.

Subgenus *Montfortia* Récluz, 1843

Type Species. By subsequent designation (Iredale, 1915), *Emarginula australis* Quoy and Gaimard, 1834.

Hemitoma (*Montfortia*) *cantonensis* new species

Figures 10, 11

Diagnosis. Generic assignment based on high-profile open-conical shell with a distinct internal groove on anterior slope. Subgeneric assignment is based on the prominent thin costa formed by selenizone, anterior slope convex with small notch at anterior margin, and posterior slope concave behind apex. Specific assignment based on the apex moderately inclined posteriorly, thin costa on anterior slope slightly left of the shell midline, and sculpture of radial ribs (at least in posterior region).

Hemitoma (*Montfortia*) *cantonensis* new species is similar to *Hemitoma* [=*Subemarginula*] *fenestrata* (Deshayes, 1864: 350, pl. 3, figs. 37–41; Cossmann and Pissarro, 1910–1913: pl. 2, fig. 10-1) from middle Eocene strata (Lutetian and Bartonian stages) of the Paris Basin, France (Chédeville, 1902: 244). *Hemitoma* (*M.*) *cantonensis* differs from *H. fenestrata* in the following features: apex higher and not as strongly inclined posteriorly. In addition, there is no evidence of any commarginal ribs on *H.* (*M.*) *cantonensis*.

Description. Shell small, open-conical, with a high profile. Apex intact, not perforated, situated about one-fourth the distance from the posterior end, moderately inclined posteriorly and having a beak-like appearance. Anterior slope convex, posterior slope concave behind apex. Anterior margin with a small notch, selenizone forming a prominent thin costa that intersects the apex slightly left of the shell midline. Exterior sculpture consists of poorly preserved radial ribs that apparently are more closely spaced in posterior region where there is also one fairly prominent rib. Interior of shell filled with matrix. Holotype height (incomplete) 6.5 mm, width (incomplete) 14 mm.

Primary Type Material. LACMIP holotype 7440, Juncal Formation, CSUN locality 358.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 358.

←

mm, width 14 mm, LACMIP holotype 7440, CSUN loc. 358. **10.** Side view, ×3.3. **11.** Dorsal view, ×2.6. **12–13.** *Monodonta* (*Incisilabium*) *piruensis* new species. All parts ×3.6, height 11 mm, width 11 mm, LACMIP holotype 7441, CSUN loc. 833. **12.** Apertural view. **13.** Abapertural view. **14.** *Nerita* (*Theliostyla*) *triangulata* Gabb, 1869, internal mold, abapertural view, ×2.8, height 12 mm, width 13 mm, LACMIP hypotype 7443, CSUN loc. 809. **15–19.** *Velates perversus* (Gmelin, 1791), adult and juvenile shells. **15.** Spiral view of adult whorl profile, ×0.9, thickness 35 mm, LACMIP hypotype 7444, CSUN loc. 850. **16.** Same specimen as shown in Figure 15, abapertural view showing spiral surace, ×1, height 55 mm. **17.** Apertural view of adult, outer lip missing, ×1.2, greatest diameter 45 mm, LACMIP hypotype 7445, CSUN loc. 830. **18.** Abapertural view showing spiral surface of an early juvenile, ×3.5, height 9 mm, LACMIP 7446, CSUN loc. 850. **19.** Abapertural view showing spiral surface of a late juvenile, ×2, height 21 mm, LACMIP hypotype 7447, CSUN loc. 850.

Remarks. Only a single specimen was found. Preservation of the critical morphologic parts is good, but the external sculpture is poorly preserved.

The specimen has the shell profile of *Puncturella* Lowe, 1827, but it does not have the perforation on the anterior slope near the apex that is diagnostic of *Puncturella.*

Montfortia has a geologic range of Eocene through Holocene and is the earliest subgenus of *Hemitoma* (Keen and Johnson, 1960a; Davies, 1971). *Hemitoma* (*M.*) *cantonensis* is presently the earliest record of *Hemitoma.* Chédeville (1902) listed four species of *Hemitoma* [=*Subemarginula*] from middle Eocene strata of the Paris Basin, but elsewhere there is a scarcity of Tertiary species, due undoubtedly to generic misidentification and preservation problems. Much taxonomic work is needed on fossil forms of emarginulinid genera closely allied to *Hemitoma;* namely, *Emarginula* and *Tauschia.*

Etymology. This species is named for Canton Canyon, Whitaker Peak area, southern California.

Superfamily Trochacea

Family Trochidae Rafinesque, 1815

Subfamily Monodontinae Cossmann, 1916

Genus *Monodonta* Lamarck, 1799

Type Species. By original designation, *Trochus labio* Linné, 1758.

Subgenus *Incisilabium* Cossmann, 1918

Type Species. By original designation, *Monodonta parisiensis* Deshayes, 1832.

Monodonta (*Incisilabium*?) *piruensis* new species

Figures 12, 13

Diagnosis. Generic assignment based on globose-turbinate shape, weak spiral sculpture, and single broad tooth at base of columella. Subgeneric assignment based on noded spiral ribs. Specific assignment based on nodose spiral ribs only on posterior half of body whorl, 18 primary spiral ribs on body whorl, and moderately thick callus along inner lip.

Monodonta (*Incisilabium*?) *piruensis* new species most closely resembles *M.* (*Incisilabium*) *parisiensis* Deshayes (1832:248–249, pl. 32, figs. 8, 9; Cossmann and Pissarro, 1910–1913:pl. 3, fig. 22-1; Wenz, 1938:299, fig. 656) from middle and late Eocene strata of the Paris Basin, France. *Monodonta* (*I.*?) *piruensis* differs from examined specimens of *M.* (*Incisilabium*) *parisiensis* in the following features: less strongly nodose spiral ribs, more closely spaced spiral ribs, nodose spiral ribs only on posterior half of body whorl rather than over entire body whorl, and about 18 rather than ten primary spiral ribs on body whorl.

Monodonta (*Incisilabium*?) *piruensis* new species superficially resembles *Homalopoma wattsi* (Dickerson, 1916:494, pl. 40, figs. 3a, b; Turner, 1938:96, pl. 15, fig. 16; Vokes, 1939:179, pl. 22, figs. 21, 22; Weaver, 1943:298, pl. 64, figs. 11, 14) from "Capay Stage" strata, Coalinga area, central California, through southwestern Oregon. *Monodonta* (*I.*?) *piruensis* differs from the holotype of *H. wattsi* in the following features: much stronger nodose primary spiral ribs, stronger spiral ribs on base of shell, large deltoid flat tooth at base of columella, thick callus along inner lip, shallow groove in umbilical area, absence of a finely spiral-ribbed collar below the suture, and absence of a tooth in center of basal lip.

Monodonta (*Incisilabium*?) *piruensis* new species also superficially resembles *Homalopoma umpquaensis* Merriam and Turner (1937:104, pl. 6, fig. 6; Turner, 1938:95–96, pl. 15, fig. 14; Weaver, 1943:299, pl. 64, figs. 20–21; Givens, 1974: 61, pl. 5, fig. 3) from "Capay" and "Domengine" "stages" strata, Pine Mountain, southern California through southwestern Oregon. *Monodonta* (*I.*?) *piruensis* differs from *H. umpquaensis* in the following features: nodose primary spiral ribs, secondary spiral ribs, seventh and eleventh spiral ribs not stronger than rest of ribs and do not form angulations at center and lower margin of the body whorl, suture much less channeled (grooved), a large deltoid flat tooth at base of columella rather than two small teeth, and a shallow groove in umbilical area.

Vokes' (1939:179–180, pl. 22, fig. 27) *Homalopoma umpquaensis domenginensis* from the Domengine Formation, Coalinga area, California, is similar to *H. umpquaensis* s.s. In addition to the features listed in the preceding paragraph, *M.* (*I.*?) *piruensis* differs from Vokes' subspecies in that *M.* (*I.*?) *piruensis* does not have a strongly angulate body whorl and does not have just a small node along the basal inner lip.

Description. Shell small, turbiniform with three or four convex whorls. Suture moderately impressed. Protoconch missing.

Penultimate whorl with four to five nodose primary spiral ribs, interspaces with a single non-nodose secondary spiral rib. Posterior half of body whorl with six nodose primary spiral ribs, interspaces with one to two smooth secondary spiral ribs. Nodosity strongest on shoulder of body whorl. Anterior half of body whorl with numerous (about 12) smooth primary spiral ribs, interspaces with one or two smooth secondary spiral ribs.

Inner lip thick with a moderately thick callus. Shallow groove in umbilical area. Columella base with a single, broad and flat deltoid-shaped tooth. Aperture circular. Outer lip missing. Holotype height (nearly complete) 11 mm, width (complete) 11 mm.

Primary Type Material. LACMIP holotype 7441, LACMIP paratype 7442, Juncal Formation, CSUN locality 833.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 833.

Remarks. Only two specimens were found. Preservation is good. *Monodonta* (*Incisilabium*) *parisiensis,* the species most similar to the new species, is the type species of *Incisilabium.* The deltoid-shaped columellar tooth in *Incisilabium*

and in *M.* (*I.*?) *piruensis* new species are identical. Assignment of *M.* (*I.*?) *piruensis* to *Incisilabium,* however, is tentative because the spiral ribs in the new species are not strongly noded over the entire shell surface.

Cossmann and Pissarro (1910–1913) assigned *M. parisiensis* to subgenus *Olivia* Cantraine, but such an assignment is not appropriate because *Olivia* is characterized by caneellate sculpture, according to Keen and Johnson (1960b).

Subgenus *Osilinus* Phillippi is somewhat similar in sculpture to that of *M.* (*I.*?) *piruensis* new species, but the columellar tooth in modern specimens of *Osilinus* in the Holocene Collection at the Los Angeles County Museum is not as strongly developed as in *M.* (*I.*?) *piruensis* and is not deltoid in shape.

The geologic range of *Monodonta* is early Paleocene (Danian) through Recent (Keen and Johnson, 1960b). *Incisilabium* is previously known only from Europe, and the geologic range of the taxon is middle and late Eocene (Cossmann and Pissarro, 1910–1913; Keen and Johnson, 1960b). *Monodonta* (*Incisilabium*?) *piruensis* new speeies is the earliest oceurrence of both *Monodonta* and *Incisilabium* on the West Coast. An early Eocene (Cuisian) occurrence of *Incisilabium* in Europe would be expected, but more collecting is needed.

Etymology. The species is named for Piru Creek, southern California.

Superfamily Neritacea

Family Neritidae Rafinesque, 1815

Subfamily Neritinae Rafinesque, 1815

Genus *Nerita* Linné, 1758

Type Species. By subsequent designation (Montfort, 1810), *Nerita peloronta* Linné, 1758.

Subgenus *Theliostyla* Mörch, 1852

Type Species. By subsequent designation (Kobelt, 1879), *Nerita albicilla* Linné, 1758.

Nerita (*Theliostyla*) *triangulata* Gabb, 1869

Figure 14

Nerita (*Theliostyla*) *triangulata* Gabb, 1869:170, pl. 28, figs. 52–52a. Vokes, 1939:182, pl. 22, figs. 31, 33–34. Givens, 1974:61, pl. 5, fig. 4. Givens and Kennedy, 1976:960, 963, pl. 1, figs. 1–4.

Nerita triangulata Gabb. Arnold, 1910:14, pl. 4, fig. 12. Arnold and Anderson, 1910:71, pl. 26, figs. 12–12a. Hanna, 1927:301, pl. 46, figs. 11–12, 16–17. Moore, 1968:28, pl. 12a. Givens and Kennedy, 1979:table 2.

Primary Type Material. Primary type material missing (Stewart, 1927:291), Domengine Formation, New Idria (Priest Valley quadrangle, T 17 S, R 12 E), California.

Molluscan Stage Range. "Domengine" through "Tejon."

Geographic Distribution. San Diego through central California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 809.

Remarks. Six internal molds were found, and they range in height from 3 to 7 mm. Although the apertural areas are obscured by matrix, the specimens show the characteristic flattened spire and three carinae on the body whorl with about four spiral ribs in the interspaces.

Genus *Velates* Montfort, 1810

Type Species. By original designation and monotopy, *Velates conoideus* (Lamarck, 1804) [=*Nerita perversa* Gmelin, 1791].

Velates perversus (Gmelin, 1791)

Figures 15–19

Nerita schmideliana sinistrorsa, fossilis Chemnitz, 1786:130, pl. 114, figs. 975–976. [Non-binomial.]

Nerita perversa Gmelin, 1791:3686. Parkinson, 1811:pl. 6, figs. 4–5. Blainville, 1825:445, pl. 36 *bis,* fig. 3.

Nerita Schmidel, 1793:41, pl. 23, figs. 1–3.

Nerita conoidea Lamarck, 1804:93. Brongniart, 1823:60, pl. 2, figs. 22a–c, misspelled as *Nerida conoidea.* Leymerie, 1878–1881:526, 538, 623, 805, pl. Z', fig. 3.

Velates conoideus (Lamarck). Montfort, 1810:354–356. Woodward, 1892:pl. 31, figs. 15–21.

Neritina conoidea Deshayes, 1832:149–151, pl. 18, figs. 1–8.

Neritina grandis J. Sowerby, 1839:328, pl. 24, fig. 9. [not *Neritina? grandis* Cooke, 1919:126, pl. 5, figs. 7–8 = *Velates vokesi* Cooke, 1946:295, new name for *Neritina? grandis* Cooke, preoccupied].

Nerita schmideliana Chemnitz. Archiac and Haime, 1854: 278, pl. 25, figs. 3, 5 (not pl. 25, fig. 4); pl. 27, figs. 1b–c. Hantken, 1875:367, pl. 18, fig. 2. Mallada, 1879:pl. 2, figs. 17–18; pl. 3, figs. 1–2.

Diceras arietina Schafhäutl, 1863:160, pl. 37, fig. 1.

Nerita schmedeliana Chemnitz. Medlicott and Blanford, 1879: 458–459, pl. 15, figs. 2–2a.

Velates schmideliana (Chemnitz). Noetling, 1894:104, pl. 2, figs. 1, 2, 7. Gregorio, 1894:31, pl. 6, fig. 181; 1896:54, pl. 6, figs. 1–3; pl. 7, figs. 1–6. Zittel, 1913:535, fig. 906. Trechmann, 1923:347–349, pl. 15, figs. 1–3.

Provelates grandis (J. Sowerby). Noetling, 1894:107–108, pl. 2, figs. 3–6.

Velates schmidelianus (Chemnitz). Zittel, 1900:454, fig. 857. Cossmann, 1925:229, pl. 6, fig. 9; pl. 7, figs. 22–23.

Velates schmideli (Chemnitz). Doncieux, 1903:358, pl. 5, figs. 9a–b. Douvillé and O'Gorman, 1929:374, pl. 31, figs. 12–12a.

Velates schmiedeli (Chemnitz). Cossmann and Pissarro, 1910–1913: pl. 6, fig. 40-1. Douvillé, 1916:25, figs. 10–11. Furon and Soyer, 1947:24, pl. 16, fig. 40-1. Pomerol and Feugueur, 1974: pl. 6, figs. 4–5.

Velates perversus (Gmelin). Cox, 1931:36–37. Vokes, 1935: 382–383, pl. 26, figs. 1–5; pl. 26, figs. 1–2. Clark and Vokes, 1936:875, pl. 1, figs. 7–8. Wenz, 1938:417, fig. 1016. Eames, 1952:12–16. Woodring, 1957:22, 66–67. Palmer, 1967:

189–190. Davies, 1971:figs. 651a, 651e, 652. Givens, 1974: 61, pl. 5, figs. 5–6, 13. Givens and Kennedy, 1979:83. Squires, 1984:16–17, figs. 6b–c. Woods and Saul, 1986: 643–647, figs. 5.17, 5.20, 5.22–5.25, 6.1–6.3, 6.8.

Velates schmiedelianus (Chemnitz). Isaeva, 1933:11, pl. 1, figs. 13–14.

Primary Type Material. Lamarck's Cabinet. No holotype was designated by Gmelin (1791), who did not have a collection but worked mainly from the literature, according to Smith (1970:459). Gmelin (1791) listed the Chemnitz Cabinet as the source of his *Nerita perversa,* and if the Cabinet is still extant, the lectotype could be designated.

Molluscan Stage Range. "Capay" through lowermost "Domengine." In Europe and India: Thanetian (late Paleocene) up to Bartonian (late middle Eocene) (Davies, 1975: 100).

Geographic Distribution. Western Europe (especially Paris Basin, France), Spain, southern France, Switzerland, Austria, northern Italy, Hungary, the Balkans, Nigeria, Egypt, Sudan, Saudi Arabia, Iraq, Iran, Pakistan, India, Tibet, Burma, Jamaica, Panama?, Florida, southern and central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 360, 818, 830, 837, 848, 850, 851, 853.

Remarks. *Velates perversus* is locally abundant in the *Turritella uvasana infera* fauna. Except at localities 360, 830, and 850, only a few specimens were found. At locality 360, 12 specimens were found, and they represent a partial growth series (height range from 8 to 27 mm). At locality 830, 22 specimens were found, and they also represent a partial growth series (height range from 7 to 29 mm). At locality 850, 36 specimens were found, and they represent a nearly complete growth series (height range from 3 to 38 mm). Preservation is good at all localities.

In early juvenile specimens whose shell height is less than 10 mm (i.e., height is parallel to axis of coiling, as shown by Woods and Saul, 1986:fig. 4), the shell profile is low-spire naticiform. There is usually no hint of an angulate shoulder (Fig. 18), and the callus on the inner lip is very thin. At about 10 mm in shell height, a very slight angulate shoulder appears on the naticiform shell. This shoulder becomes more strongly developed (along with a very low spire) with age, especially in specimens whose shell height is 20 to 30 mm (Fig. 19). In specimens whose shell height is greater than about 20 mm, there is a characteristic patelliform profile and an extensive inner-lip callus that covers the apertural face. The callus is thick and convex. This change from low-spired naticiform early juveniles to patelliform adults was also observed in this species by Woods and Saul (1986).

There are seven to eight unequally arranged small teeth in *V. perversus.* In juvenile specimens both the anteriormost and posteriormost teeth bifurcate to achieve this full tooth count, as also observed by Vokes (1935) and Woods and Saul (1986) in their studies of this species.

The best preserved specimens in the Whitaker Peak section have closely spaced, fairly prominent growth lines on the abapertural surface of the shell. On some of the adult specimens, the spire is noticeably projecting. These morphologic features, as well as all the above-mentioned morphologic features, were also seen on Los Angeles County Museum of Natural History collection specimens of *V. perversus* from the Paris Basin.

Woodring (1957:66–67, pl. 14, figs. 5–8) illustrated a *V. perversus* subsp.? that differs from *V. perversus* only in the presence of a wide rim along the outer lip. *Velates perversus* subsp.? is from the middle Eocene portion of the Gatuncillo Formation of the Panama Canal Zone. As noted by Woods and Saul (1986), whether the outer lip rim is a specific, subspecific, or ecophenotypic characteristic has not been determined.

Chemnitz's (1786) name of *Nerita schmideliana sinistrorsa, fossilis* cannot stand because it is not a binomial name. For a complete synonymy of *Velates perversus,* see Eames (1952).

Order Mesogastropoda

Superfamily Cerithiacea

Family Turritellidae Woodward, 1851

Genus *Turritella* Lamarck, 1799, s.l.

Type Species. By monotypy, *Turbo terebra* Linné, 1758.

Turritella andersoni Dickerson, 1916

Figures 20, 21

Turritella andersoni Dickerson, 1916:501–502, pl. 42, figs. 9a–b. Turner, 1938:83, pl. 22, figs. 4–6. Merriam, 1941: 76–77, pl. 9, figs. 1–2; pl. 10, figs. 1, 3–5, 8; pl. 12, figs. 1–3. Hanna and Hertlein, 1941:figs. 62-6, 62-7, 62-16. Givens, 1974:62, pl. 5, figs. 7–10. Squires, 1984:16–17, fig. 6e.

Turritella andersoni susanae Merriam, 1941:79, pl. 11, fig. 6. Saul, 1983:pl. 2, fig. 5.

Primary Type Material. UCMP holotype 12131, UCMP paratype 12132, UCMP plastoparatype 12132, Arroyo Hondo Formation, UCMP locality 1817. Both holotype and paratype missing since 1959.

Molluscan Stage Range. "Meganos"? through "Capay."

Geographic Distribution. Simi Valley, southern California through southwestern Oregon. Weaver (1937:29) also noted occurrence of *T. andersoni* (no specimens listed or illustrated) from Victoria, British Columbia.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 359, 360, 362, 803, 805, 811, 815, 816, 817, 818, 819, 821, 822, 824, 825, 829, 835, 837, 843, 846, 847.

Remarks. *Turritella andersoni* is one of the more common macrofaunal components of the *Turritella uvasana infera* fauna in the Whitaker Peak section. It is especially abundant at localities 362, 816, 817, 819, 822, 825, 829, and 846. Preservation is generally fair to poor.

Specimens of *T. andersoni* from the Whitaker Peak section agree with the ornamentation observable on the plastoparatype. The plastoparatype must be used because the holotype

and paratype are missing. Dickerson (1916:501, pl. 42, fig. 9a) briefly described the holotype but did not describe the paratype. Because the plastoparatype is all that remains of the primary type material to compare with and because no worker previously described it, a description of UCMP plastoparatype is given below. The plastoparatype (height 24 mm) is characterized by a whorl profile that is very broadly and shallowly concave medially between a pair of broadly spaced primary spiral ribs. The whorl surface between the anterior rib and the suture is usually flattened, but it can be somewhat concave. The anteriormost primary is the stronger of the two ribs. The posterior primary can have small nodes. A third but weaker primary spiral rib occurs between the anterior and posterior primaries and is slightly closer to the posterior primary than it is to the anterior primary. This third, weak primary is usually noded. Between the posterior primary and the suture, there is a secondary spiral rib that can almost approach the strength of the posterior primary. This secondary spiral rib can be noded. When this secondary is strong, the whorl profile is somewhat flattened in this area. Three secondary ribs (which can be noded) are present on the concave median area of the whorl, with one between the posterior and median primaries and two between the median and anterior primaries. There can be a single secondary between the anterior primary and the suture. Tertiary spiral threads are difficult to discern on the plastotype, but there are faint indications of their presence in the area between the posterior primary and the median primary.

In the Whitaker Peak section, rare individuals (ecotypes) of *T. andersoni* can have their whorls covered by numerous secondary spiral ribs, all of equal strength (Fig. 21). Tertiary spiral ribs occur between the secondary ribs. Ribs are so numerous and so closely spaced as to obscure the suture. The anteriormost area of the whorl is swollen. At locality 835, there are two specimens like this among 11 typical specimens. At localities 803 and 843, there are one and two specimens, respectively, covered with these numerous spiral ribs and there are no typical specimens.

The lower molluscan stage range limit of *T. andersoni* (i.e., "Meganos Stage") is queried because there is confusion regarding the stratigraphic nomenclature of the type locality. The area of UCMP 1817, the holotype locality of *T. andersoni,* was first mentioned by Dumble (1912:32), who used the Coalinga quadrangle map of 1912, and later by Anderson and Pack (1915:60). Dickerson (1916:423) reiterated Dumble's locality information. Vokes (1939:188) gave somewhat more specific information and included the locality in his Arroyo Hondo Formation. Merriam (1941:77) assigned the locality to the "Capay Stage." Clark (1943) considered Vokes' Arroyo Hondo Formation to be equivalent to the "Capay Stage." Keen and Bentson (1944:209–210) assigned the locality to the Cerros Shale Member of the Lodo Formation, but they wrote "SE ¼ NW ¼ 15" rather than "SW ¼ NW ¼ section 15" of previous workers. Stinemeyer (1974) also mentioned that the *T. andersoni* material in the general area of the holotype locality should be placed in the upper part of the Cerros Shale Member of the Lodo Formation and should be equivalent to Laiming's (1940a) C Zone ("Capay Stage.") Moore (1984:9), however, assigned the Cerros Shale Member, as well as UCMP locality 1817, to the Paleocene. Until more stratigraphic work and re-collecting are done in the type area, assignment of *T. andersoni* to the "Meganos Stage" is tentative.

Saul (1983:71, 73, pl. 1, figs. 15–18) reported *T. andersoni* new subspecies from the upper 90 m of the Santa Susana Formation in Simi Valley, California. That portion of the formation is late Paleocene/early Eocene in age ("Meganos Stage") (Filewicz and Hill, 1983; Saul, 1983; Squires, 1984). Saul (1983) mentioned that some of these specimens are very close to *T. andersoni* Dickerson, especially some from localities near the contact with the overlying Llajas Formation. I have collected numerous specimens of Saul's *T. andersoni* new subspecies, and I agree that they have very close affinity with *T. andersoni.* The upper Santa Susana Formation specimens, however, have an additional prominent primary spiral rib in the anterior portion of the whorl that equals the anteriormost prominent primary, and the whorl surface between this anteriormost primary and the suture is not as flat or as noticeable as in *T. andersoni.* At this time, I regard the two as separate taxa.

Turritella meganosensis protumescens Merriam and Turner, 1937

Figure 22

Turritella meganosensis new subspecies Clark, 1929:pl. 10, figs. 1–2.

Turritella meganosensis protumescens Merriam and Turner, 1937:104, pl. 6, figs. 8–10. Turner, 1938:85, pl. 22, fig. 15. Merriam, 1941:75–76, pl. 8, figs. 1–2, 5, 6, 8. Weaver, 1943:369–370, pl. 74, figs. 14, 18. Saul, 1983:pl. 2, fig. 1. Squires, 1984:17, fig. 6d.

Primary Type Material. UCMP holotype 15353, "basal conglomerate" of the Llajas Formation, UCMP locality 7195.

Molluscan Stage Range. "Capay."

Geographic Distribution. Simi Valley, southern California through southwestern Oregon.

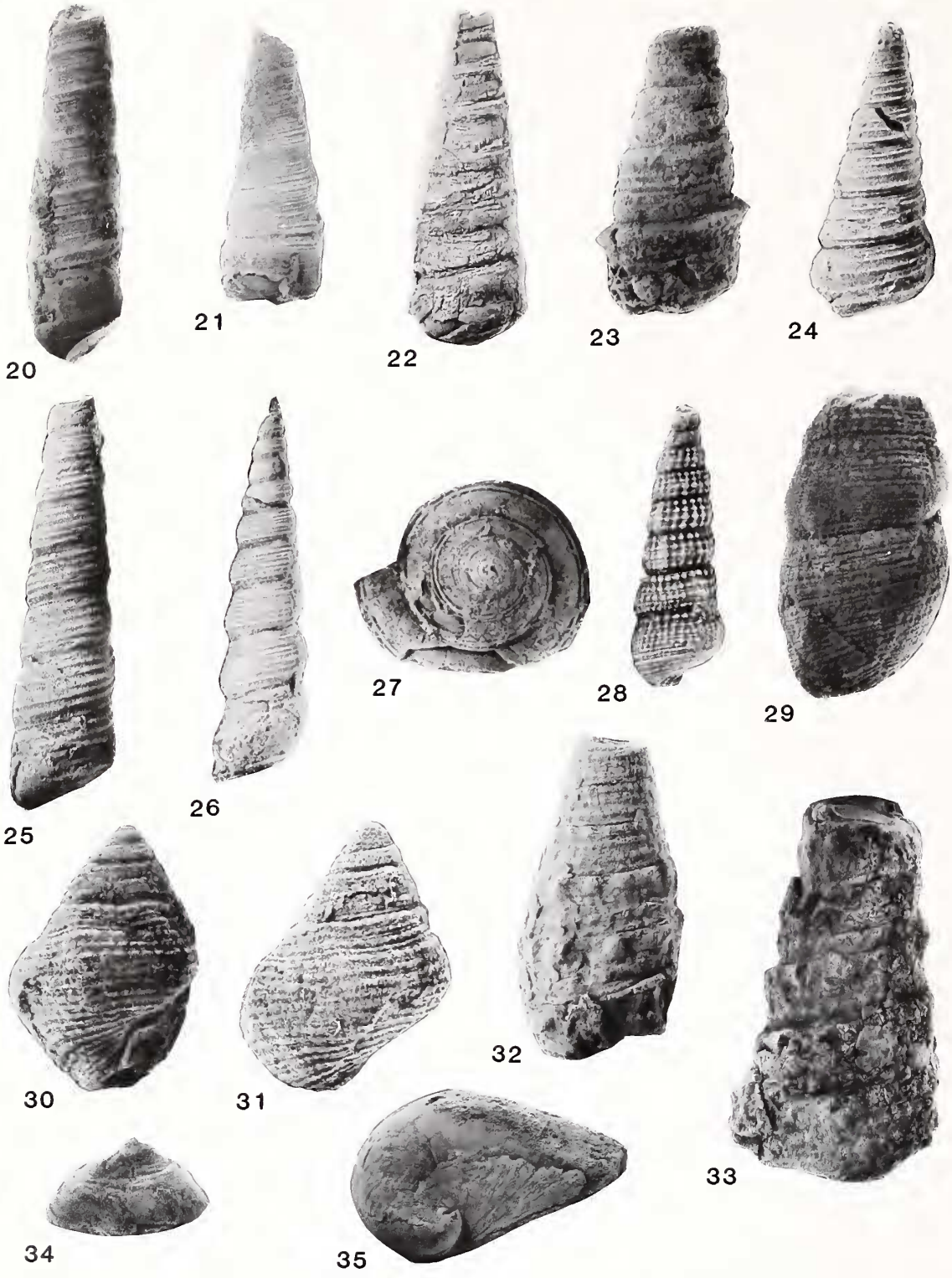
Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 846, UCLA locality 4713.

Remarks. This distinctive taxon is rare in the Whitaker Peak section. Four specimens were found at UCLA locality 4713, and only one specimen was found at CSUN locality 846. Preservation is fair to good. Specimens occur in the middle of the *Turritella uvasana infera* faunal zone of the Whitaker Peak section. This taxon was not found by Givens (1974) in the *T. uvasana infera* fauna of the Juncal Formation, Pine Mountain section.

Turritella merriami Dickerson, 1913

Figure 23

Turritella merriami Dickerson, 1913:284–285, pl. 13, figs. 6a–6c; 1916:pl. 39, fig. 10. McLaughlin and Waring, 1915: fig. 23. Clark and Woodford, 1927:119 (in part), pl. 21, fig. 7. Clark, 1929:pl. 5, fig. 6. Merriam and Turner, 1937: 91–92, 94–95, 97, 101. Vokes, 1939:35–36. Merriam, 1941:



Figures 20–35. Whitaker Peak area Eocene mesogastropods. Unless otherwise indicated, views are abapertural. **20.** *Turritella andersoni* Dickerson, 1916, side view, ×1.6, height 36 mm, width 9 mm, LACMIP hypotype 7448, CSUN loc. 362. **21.** Ecotype of *Turritella andersoni* Dickerson, 1916, ×1.8, height 24 mm, width 9 mm, LACMIP hypotype 7449, CSUN loc. 843. **22.** *Turritella meganosensis protumescens* Merriam and Turner, 1937, ×1.25, height 42 mm, width 14 mm, LACMIP hypotype 7450, CSUN loc. 846. **23.** *Turritella merriami* Dickerson, 1913, ×2.3, height 20 mm, width 10.5 mm, LACMIP hypotype 7451, CSUN loc. 358. **24.** *Turritella buwaldana* Dickerson, 1916, ×3.4, height 14 mm, width 5.5 mm, LACMIP hypotype 7452, CSUN loc. 237. **25.** *Turritella uvasana infera* Merriam, 1941, ×1.5, height 43 mm,

83–84, pl. 13, fig. 11; pl. 14, figs. 8–16. Hanna and Hertlein, 1941:fig. 62-25. Weaver, 1953:43.

Not *Turritella merriami* Dickerson. Clark and Woodford, 1927:119 (in part), pl. 21, figs. 6, 8–9 [=*Turritella merriami brevitabulata* Merriam and Turner *fide* Merriam, 1941].

Turritella merriami Dickerson var. Turner, 1938:85–86, pl. 22, figs. 8–9. Weaver, 1943:369, pl. 74, fig. 10.

Primary Type Material. UCMP syntypes 12127, 12133, "Capay Stage" Sutter Buttes [=Marysville Buttes], Sutter County, northern California, UCMP locality 1855.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Whitaker Peak area, southern California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 803?

Remarks. *Turritella merriami* is very rare in the Whitaker Peak section as only one positively identified specimen was found. Preservation is fair. This species is characterized by the very prominent posterior tabulation and spiral flange immediately below the suture. Below the flange there are four primary spiral ribs of equal strength.

Previously, this species has not been reported south of the San Joaquin Valley, California. It commonly occurs with *Turritella andersoni* elsewhere in California, and the two are questionably found together at CSUN locality 803, along with *T. uvasana infera*. The only "Domengine Stage" occurrence of *T. merriami* is in the Muir Sandstone near Martinez, California (Weaver, 1953).

Merriam (1941:83–84, pl. 13, fig. 11; pl. 14, fig. 16) equated the hypotypes (UCMP 33280 and 33279) of Turner's (1938: 85–86, pl. 22, figs. 8, 9) *Turritella merriami* Dickerson var. to *Turritella merriami* Dickerson.

Turritella buwaldana Dickerson, 1916

Figure 24

Turritella buwaldana Dickerson, 1916:500–501, pl. 42, figs. 7a–b. Hanna, 1927:307, pl. 49, figs. 7–8, 12. Merriam, 1941:86–87, pl. 21, figs. 3–9; pl. 22, figs. 1–14. Stewart, 1946:pl. 11, fig. 24. Givens, 1974:63, pl. 5, fig. 15. Saul, 1983:pl. 2, figs. 13–15. Squires, 1983b:fig. 9f; 1984:18, fig. 6h.

Turritella kewi Dickerson, 1916:501, pl. 42, fig. 8.

Primary Type Material. UCMP holotype 12130, Domengine Formation, UCMP locality 672.

Molluscan Stage Range. Upper "Meganos"?, "Capay"?, "Domengine" through "Tejon."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN localities 363, 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. About five specimens were found at each locality. Preservation is fair and the specimens are small fragments.

Turritella buwaldana in the Whitaker Peak section is characterized by the presence of three primary spiral ribs and one to two slightly weaker posterior spiral ribs. Tertiary ribs (usually one) are in the interspaces. On two specimens from locality 828, however, all the primaries, except the posteriormost, are of equal strength and have small nodes.

Turritella uvasana infera Merriam, 1941

Figure 25

Turritella uvasana infera Merriam, 1941:90, pl. 40, figs. 2–4. Givens, 1974:65–66, pl. 6, figs. 5–7. Saul, 1983:pl. 1, fig. 19; pl. 2, fig. 4. Squires, 1984:19, fig. 6i.

Primary Type Material. UCMP holotype 33993, "basal conglomerate" of the Llajas Formation, UCMP locality A-994; UCMP paratypes 15439 and 15443, upper part of the Santa Susana Formation, UCMP locality 7000.

Molluscan Stage Range. Upper "Meganos" through "Capay."

Geographic Distribution. Simi Valley, Whitaker Peak area, and Pine Mountain area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 359?, 361, 802, 803, 805, 806, 811, 812, 813, 815, 816, 817, 819, 820, 821, 822, 824, 827, 834, 835, 838, 841, 844, 845, 846, 847, 850.

Remarks. *Turritella uvasana infera* is one of the more common macrofaunal components of the *Turritella uvasana infera* fauna in the basal part of the Whitaker Peak section. Preservation is generally good to excellent. Specimens are particularly well preserved and abundant at localities 803, 805, 838, and 847. At the other localities, about ten to 15 specimens were found, except at localities 359?, 361, 802, 827, 834, 844, and 850 where only one or two specimens were found. At locality 845, all the specimens consist only of apical parts.

←

width 10.5 mm, LACMIP hypotype 7453, CSUN loc. 805. **26.** *Turritella uvasana applinae* Hanna, 1927, ×1.5, height 38 mm, width 10 mm, LACMIP hypotype 7454, CSUN loc. 219. **27.** *Architectonica* (*Stellaxis*) *cognata* Gabb, 1864, dorsal view, ×2.6, greatest diameter 14 mm, LACMIP hypotype 7455, CSUN loc. 358. **28.** *Bittium*? *dumblei* (Dickerson, 1916), ×4, height 11 mm width 3.5, LACMIP hypotype 7456, CSUN loc. 845. **29.** ?*Pseudovertagus* (*Pseudoaluco*) sp., ×2, height 25 mm, width 13 mm, LACMIP hypotype 7457, CSUN loc. 360. **30–31.** *Benoistia cantonensis* new species. All parts ×3, height 14 mm, width 9 mm, LACMIP holotype 7458, CSUN loc. 802. **30.** Apertural view. **32–33.** *Campanile* new species? All parts upper spire, CSUN loc. 837. **32.** ×1.6, height 32 mm, width 16.5 mm, LACMIP hypotype 7459. **33.** ×1.3, height 46 mm, width 24 mm, LACMIP hypotype 7460. **34.** *Calyptraea diegoana* (Conrad, 1855), side view, ×1.6, height 9 mm, width 15 mm, LACMIP hypotype 7461, CSUN loc. 827. **35.** *Crepidula* new species, dorsal view, ×1.2, length 37 mm, height 22 mm, LACMIP hypotype 7462, CSUN loc. 827.

At 14 of the 27 localities where it occurs, *T. uvasana infera* is found with *T. andersoni. Turritella uvasana infera,* however, was not found in the Canton Canyon area proper (section 1, T 5 N, R 18 W) although *T. andersoni* is present there.

Specimens of *T. uvasana infera* from the Whitaker Peak section have whorls that are gently convex to flat and ornamented by five to six (commonly just five) heavy spiral ribs of the same or nearly same strength. Tertiary interribs are rarely present. In some specimens, the two posteriormost ribs can be slightly offset from the other primaries.

The presence of *T. uvasana infera* in the Whitaker Peak section is only the fourth location in which this species has been reported. One location is the upper part of the late Paleocene/earliest Eocene Santa Susana Formation (upper "Meganos Stage" portion) in Simi Valley, California (Merriam, 1941; Saul, 1983; Squires, 1984). Merriam (1941) and Saul (1983), however, mentioned that these specimens have a more rounded whorl profile and heavier ribbing than those from the type locality low in the overlying Llajas Formation, the second place this taxon has been reported. I have also collected specimens from both horizons, and I agree with the comments of Merriam (1941) and Saul (1983). The sutural area in the upper Santa Susana specimens also can be much more sunken. Specimens, however, show variability in all the above-mentioned features. Variability is, in fact, a characteristic of this subspecies (Merriam, 1941). Some of the upper Santa Susana specimens are indistinguishable from the Whitaker Peak section specimens.

The type locality of *T. uvasana infera* is from the interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies in the lower part of the Llajas Formation ("Capay Stage" portion) in Simi Valley, California (Saul, 1983; Squires, 1984). Specimens of *T. uvasana infera* from the Whitaker Peak section are like those of the Llajas Formation in having slightly convex whorls, six or seven primary spiral ribs with the two posteriormost ones slightly offset from the other primaries, and the two posteriormost primaries somewhat weaker than the other primaries. The number of ribs, however, may be one or two less in the Whitaker Peak specimens.

The third location from which *T. uvasana infera* has been previously reported is the *T. uvasana infera* fauna of the Juncal Formation ("Capay Stage" portion) in the Pine Mountain area (Givens, 1974). Specimens of *T. uvasana infera* from the Whitaker Peak section are more like the specimens from the Pine Mountain area than anywhere else.

Givens (1974) mentioned that *T. uvasana hendoni* var. B Turner from the lower Umpqua Formation in southern Oregon resembles *T. uvasana infera* except that *T. uvasana infera* has a slightly less convex whorl profile. After examining the types of *T. uvasana hendoni* var. B Turner (1938: 85, pl. 22, figs. 7, 10, 12, 13; Weaver, 1943:367, pl. 74, fig. 21), as well as the holotype and illustrations of the paratypes of *T. uvasana hendoni* Merriam s.s. (Turner, 1938:84, pl. 21, figs.7, 12–16; Merriam, 1941:91–93, pl. 17, figs. 1–7; Weaver, 1943:366–367, pl. 74, figs. 1, 6), and the types of *T. uvasana hendoni* var. A Turner (1938:84, pl. 22, figs. 11, 14; Merriam, 1941:91–93, pl. 17, figs. 8, 9; Weaver, 1943:367, pl. 74, fig. 2), I conclude the following: 1) two of the specimens (UCMP 33283 and 33284) of *T. uvasana hendoni* var. B have very close affinity to *T. uvasana infera* except the whorls are more convex (as Givens (1974) noted); 2) the other two specimens (UCMP 33285 and 33286) of *T. uvasana hendoni* var. B, however, more closely resemble *T. uvasana applinae* Hanna because the whorls are more convex and covered with more ribs than in *T. uvasana infera;* 3) the holotype (UCMP 33288) of *T. uvasana hendoni* s.s. has close affinity to *T. uvasana infera* except there are three additional secondary ribs in the posterior portions of the very flat-sided whorls, but in the paratypes of *T. uvasana hendoni* s.s. the whorl convexity can be considerable; and 4) the specimens (UCMP 33281 and 33282) of *T. uvasana hendoni* var. A are somewhat similar to *T. uvasana infera* except that the convex whorls have very wide areas around the very pronounced, deep sutural areas in which there are no principal ribs. Turner (1938), Merriam (1941), and Weaver (1943) noted that *T. uvasana hendoni* var. A is from the Tyee Formation and is younger than the other forms of *T. uvasana hendoni* which are from the Umpqua Formation. Merriam (1941) also noted that *T. uvasana hendoni* var. A may warrant a separate subspecies designation, and I would agree. *Turritella uvasana hendoni* s.s. and *T. uvasana hendoni* var. B seem to be a single taxon that lies between *T. uvasana infera* and *T. uvasana applinae.* Givens (1974) noted that *T. uvasana infera* is probably ancestral to all other members of the *T. uvasana* stock.

Givens (1974) also mentioned that *T. uvasana* n. var. Crowell and Susuki (1959:pl. 2, fig. 10) from the lower Maniobra Formation in the Orocopia Mountains, Riverside County, southern California, resembles *T. uvasana infera.* Crowell and Susuki's (1959) specimen (UCLA 28986) is from CSUN 662 [=UCLA locality 3779], which Squires and Advocate (1986) showed to be "Capay" in age. After examining the specimen, as well as numerous others that I collected from this locality, I conclude that *T. uvasana* n. var. Crowell and Susuki differs from *T. uvasana infera* in the following features: slightly more convex whorl profile, minutely noded posterior ribs, and commonly occurring interribs. *Turritella uvasana* n. var. is more similar to *T. uvasana hendoni* var. B Turner represented by specimens UCMP 33283 and 33284.

Turritella uvasana applinae Hanna, 1927

Figure 26

Turritella applini Hanna, 1927:307, pl. 49, figs. 1, 4. Clark, 1929:pl. 10, figs. 8, 18.

Turritella uvasana applini Hanna. Merriam, 1941:93–94, pl. 16, figs. 5–6; pl. 18, fig. 2.

Turritella uvasana etheringtoni Merriam, 1941:94, pl. 15, figs. 12–15. Squires, 1977:table 1.

Turritella uvasana applinae Hanna. Moore, 1968:28, pl. 12e. Givens, 1974:66, pl. 6, figs. 3–4; pl. 7, fig. 19. Givens and Kennedy, 1979:82–83, table 1. Saul, 1983:pl. 2, fig. 18. Squires, 1983b: fig. 9g; 1984:19, fig. 6j.

Primary Type Material. UCMP holotype 30971, UCMP

locality 3993; UCMP paratype 33894, UCMP locality 3990; La Jolla Group.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego through Pine Mountain area, southern California.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 363. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 231, 237, 808, 809?

Remarks. *Turritella uvasana applina* is a fairly common macrofaunal component of the *Turritella uvasana applinae* fauna in Whitaker Peak section. At locality 237 about 35 specimens were found. At the other localities, there are five to seven specimens. Preservation is excellent at all localities.

Turritella uvasana applinae is one of the most diagnostic taxa of the "Domengine Stage." This subspecies is characterized by very convex whorls ornamented by numerous spiral ribs. There are two to three posterior secondary ribs, five to six primary ribs, and one to two anterior secondary ribs. Several fine tertiary ribs may be present in the interspaces between all the primary and secondary ribs. As mentioned by Givens (1974), *T. uvasana applinae* is distinguished from its probable ancestor, *T. uvasana infera,* by a more convex whorl profile, a greater number of less coarse spiral ribs, presence of secondary ribs, and common occurrence of tertiary ribs.

Family Architectonicidae Gray, 1850

Genus *Architectonica* Röding, 1798

Type Species. By subsequent designation (Gray, 1847a), *Trochus perspectivus* Linné, 1758.

Subgenus *Stellaxis* Dall, 1892

Type Species. By original designation, *Solarium alveatum* Conrad, 1833.

Architectonica (*Stellaxis*) *cognata* Gabb, 1864

Figure 27

Architectonica cognata Gabb, 1864:117, pl. 20, figs. 72, 72a, 72c, not d and e as stated [not 72b = *A. alveata* (Conrad) *fide* Stewart, 1927:344]. Givens and Kennedy, 1979:83, table 1.

Stellaxis cognata (Conrad). Waring, 1917:98.

Architectonica (*Stellaxis*) *cognata* Gabb. Stewart, 1927:343–344, pl. 28, figs. 7–8; 1946:pl. 11, fig. 4. Turner, 1938:90, pl. 18, fig. 17. Vokes, 1939:163–164. Weaver, 1943:363–364, pl. 73, fig. 20; pl. 103, fig. 19. Givens, 1974:68, pl. 7, figs. 1–3.

Primary Type Material. ANSP lectotype 4223, designated by Stewart (1927:343), Tejon Formation s.l., 11 km south of Martinez, California.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 358.

Remarks. Only two specimens were found, and preservation is good. The presence of this taxon in the *Turritella uvasana infera* fauna of the Whitaker Peak section extends the molluscan stage range of this species into the "Capay Stage" proper. Previously, the lower range limit had been known to be uppermost "Capay" (Squires, 1984).

Family Cerithiidae Fleming, 1822

Subfamily Cerithiinae Fleming, 1822

Genus *Bittium* Leach *in* Gray, 1847b

Type Species. By subsequent designation (Gray, 1847a), *Murex reticulatus* (Montagu, 1803) [=*Strombiformis reticulatus* Costa, 1778].

Bittium? *dumblei* (Dickerson, 1916)

Figure 28

Cerithiopsis alternata Gabb, 1864:116, pl. 21, figs. 114–114a. Waring, 1917:90, pl. 15, fig. 3. Clark, 1929:pl. 10, fig. 5.

Not *Cerithium alternatum* G.B. Sowerby, 1855:872, pl. 179, figs. 70, 73.

Cerithiopsis dumblei Dickerson, 1916:489, pl. 38, fig. 12. Cossmann, 1916:110 (said to resemble *Bittium*).

Cerithium dumblei (Dickerson). Stewart, 1927:354–356, pl. 26, fig. 15.

Bittium (?) *dumblei* (Dickerson). Vokes, 1939:158–159, pl. 20, fig. 3.

Cerithium? *dumblei* (Dickerson). Keen and Bentson, 1944: 142.

Bittium dumblei (Dickerson). Givens and Kennedy, 1976: 965.

Primary Type Material. ANSP lectotype 4218 of *Cerithiopsis alternata* Gabb, designated by Stewart (1927:354), Eocene, Martinez, California. UCMP holotype 11805 of *Cerithiopsis dumblei* Dickerson, Domengine Formation, UCMP locality 672.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley, southern California through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 827, 835, 845. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 237.

Remarks. Fourteen fragmental specimens were found, and eight are from locality 845. Height range is from 4 to 10 mm. Apertural areas are missing.

This small species is characterized by a nearly flat-sided whorl profile and a sculpture of four spiral ribs crossed by numerous equal-strength collabral costae with nodes at the intersections. Usually there are two weak varices per whorl. The spiral ribs are equally spaced and of equal strength. Between each rib is an unnoded fine spiral thread, as reported by Stewart (1927) and Vokes (1939). This particular feature

becomes more apparent anteriorly. The base of the body whorl is angulated. There is a definite anterior canal but it is short.

Bittium? *dumblei* resembles *Cerithiopsis orovillensis* Dickerson (1916:489–490, pl. 39, fig. 7) from "Capay" strata, Sutter Buttes [=Marysville Buttes], northern California, but is distinguished by the following features: longer, more parallel-sided, equal-strength primary spiral ribs, only one keel rather than two on the base of the body whorl, an unnoded keel, and less prominent varices.

Generic assignment of *Bittium*? *dumblei* has long been uncertain. The most important morphologic characteristic is the nature of the anterior canal, which is poorly preserved in both Gabb's (1864) and Dickerson's (1916) primary type material. Vokes (1939) collected topotype material from Dickerson's locality but still could not positively determine if the species belongs in *Bittium*. In this present study, Vokes' tentative determination is used. It is possible, however, that a study of future, better preserved specimens may show that this species belongs in the closely allied genus *Cerithiopsis*. Previously, this species has not been reported as ranging into the "Capay Stage."

Genus *Pseudovertagus* Vignal, 1904

Type Species. By original designation, *Cerithium aluco* Linné, 1758.

Subgenus *Pseudoaluco* Clark and Durham, 1946

Type Species. By original designation, *Cerithium jussieui* Mayer-Eymar, 1870.

?*Pseudovertagus* (*Pseudoaluco*) sp.

Figure 29

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 360, 811.

Remarks. Only two specimens were found. One consists of a single whorl, and in a larger specimen (Fig. 29), the upper part of the spire and the anterior end are missing. Positive identification is not possible due to the fragmentary condition of the specimens. The larger specimen (height 25 mm) has primary and secondary spiral ribbing. The primary spirals are beaded, and the beads are aligned axially, forming very weak collabral riblets. The beading and collabral riblets become obsolete on the anterior whorls. There is a wavy, distinct suture and one or two slight broad varices per whorl. All of these features are present in *Pseudoaluco* (Clark and Durham, 1946:28; Houbrick, 1978:116). The anterior portion of the penultimate whorl is swollen.

The Whitaker Peak specimens resemble *P.* (*P.*) *jussieui* (Mayer-Eymar, 1870:87; Cossmann, 1906:pl. 3, figs. 1, 2; Cossmann and Pissarro, 1910–1913:pl. 24, fig. 137-23; Houbrick, 1978:116, pl. 89) from middle Eocene strata (Lutetian Stage) of the Paris Basin, France. The Whitaker Peak specimens differ from an examined specimen of the Paris basin species in the following features: smaller, more inflated whorls, absence of the fairly strong collabral costae, absence of cancellate sculpture, and not beaded (pustulate) over the entire surface of the shell.

The Whitaker Peak specimens also resemble *Pseudovertagus vectensis* Wrigley (1941:161–162, figs, 1a–c) from middle Eocene strata of the Isle of Wight, southern England. The Whitaker Peak specimens are not beaded over the entire surface of the shell and have more primary spiral ribs on each whorl. Clark and Durham (1946) pointed out that Wrigley's species should be assigned to subgenus *Pseudoaluco*.

According to Houbrick (1978), *Pseudovertagus* s.l. has its origin in the Paleocene, and the subgenus *Pseudoaluco* is a Paris Basin taxon confined to the Eocene. If the Whitaker Peak specimens belong to *Pseudovertagus* (*Pseudoaluco*), then it would be the first time this genus and subgenus have been reported from the West Coast of North America, as well as the earliest occurrence of the subgenus. Clark and Durham (1946) reported two species of the subgenus from middle through late Eocene strata in Colombia, South America, but Houbrick (1978) could not justify placing them in this subgenus because of their fragmentary condition.

Genus *Benoistia* Cossmann, 1899

Type Species. By original designation, *Cerithium muricoides* Lamarck, 1804.

***Benoistia cantonensis* new species**

Figures 30, 31

Diagnosis. Generic assignment based on the small, turbiniform shell, medially angulate whorls with unaligned varices, small angle at suture, and whorls covered with numerous alternating primary and secondary beaded spiral ribs. Specific assignment based on the four varices centered on the medial angulation of the body whorl and 18 narrowly spaced primary beaded spiral ribs on the body whorl.

Benoistia cantonensis new species is very similar to *Benoistia breviculum* (Deshayes, 1824–1837:425–426, pl. 61, figs. 9–12; Cossmann and Pissarro, 1910–1913:pl. 23, fig. 136-2) from early Eocene strata (Cuisian Substage) of the Paris Basin, France. *Benoistia cantonensis* differs from numerous examined specimens of *B. breviculum* in the following features: narrower interspaces between primary ribs, fewer secondary spiral ribs, weaker varices on the spire whorls, and 18 rather than ten primary spiral ribs covering the body whorl. Also, *B. cantonensis* has less beaded primary and secondary ribs, but this difference may be due to preservation.

Benoistia cantonensis new species is somewhat similar to

B. umpquaensis Turner (1938:82, pl. 21, figs. 8, 10; Vokes, 1939:164–165, pl. 21, figs. 1, 3, 4 [=*Tectarius ligniticus* Vokes, 1939]; Givens and Kennedy, 1976:964–965, pl. 1, figs. 14–21) from "Domengine Stage" strata in California and southwestern Oregon. *Benoistia cantonensis* differs from *B. umpquaensis* in the following features: only four varices on the middle portion of the body whorl rather than seven or eight, no varices or only faint ones on the spire whorls, and about 11 primary spiral ribs on the base of the body whorl instead of seven.

Description. Shell small, turbiniform, with five and one-half whorls. Spire whorls flat-sided. Suture slightly grooved. Body whorl medially angulate. Four rounded, oblique varices centered on medial angulation of body whorl. Some specimens with a few faint varices on the spire whorls. Varices not aligned. Small but noticeable angulation just anterior to the suture. Spire about one-fourth the height of the shell. Protoconch low, dome-like, and apparently smooth. Spire whorls with about four beaded primary spiral ribs alternating with beaded secondary spiral ribs that can approach the primaries in strength. Body whorl covered with beaded primary spiral ribs alternating with beaded secondary spiral ribs. On the body whorl and spire whorls, the primary spiral rib just anterior to the suture has the largest beads. Generally, there are 18 primaries, seven posterior to and including the medial angulation and 11 on the base of the body whorl (i.e., anterior to the medial angulation).

Aperture either obscured with matrix or missing. Columella apparently smooth. Holotype height (incomplete) 14 mm, width (complete) 9 mm.

Primary Type Material. LACMIP holotype 7458, Juncal Formation, CSUN locality 802.

Molluscan Stage Range. "Capay Stage."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 364, 802.

Remarks. Three nearly complete and two fragmental specimens were found. The nearly complete specimens range in height from 14 to 18 mm.

According to Wenz (1940), *Benoistia* ranges from Paleocene into the Oligocene and is restricted to Europe. Five species, including the type species, have been reported from Paris Basin, France, Eocene strata. *Benoistia brevicula* (Deshayes) is the only species from the early Eocene (Cuisian) in that area.

Benoistia cantonensis new species is the earliest species of this genus from West Coast strata. Previously, *B. umpquaensis* Turner from middle Eocene ("Domengine Stage") strata in California and southwestern Oregon was the earliest. *Benoistia californica* Clark (1938:708, pl. 3, figs. 2–4) from the late Eocene "Tejon Stage" Markley Formation of northern California is the only other previously reported species of *Benoistia* from the West Coast.

Etymology. The species is named for Canton Canyon, Whitaker Peak area, southern California.

Family Campanilidae Douvillé, 1904

Genus *Campanile* Fischer, 1884

Type Species. By subsequent designation (Sacco, 1895), *Cerithium giganteum* Lamarck, 1804.

Campanile new species?

Figures 32, 33

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 837.

Remarks. Only four fragments of upper spires were found, and preservation is poor to fair. The largest specimen (Fig. 33) is 46 mm in height. Specimens of *Campanile* new species? have a noded carina on the shoulder of each whorl. The carina, nodes, and parallel-sided whorls become more prominent with increasing age. There are 11 to 13 nodes on the carina. Anterior to the carina are two or three primary spiral ribs with numerous low nodes.

The material may constitute a new species, but beeause the specimens are so incomplete, a positive determination cannot be made at this time.

Campanile new species? is similar to the only described Eocene species of *Campanile* on the West Coast, namely, *C. dilloni* (Hanna and Hertlein, 1949:392–394, pl. 77, figs. 2, 4; text fig. 1; Givens, 1974:69, pl. 7, fig. 10; Squires and Advocate, 1986:853, 855, fig. 2.1) from early Eocene strata of southern and south-central California. Although the specimens of *Campanile* new species? represent more youthful growth stages than are known for *C. dilloni,* as best as can be determined from the most mature portion of *C.* new species? and the most youthful portion of *C. dilloni, C.* new species? has fewer carina nodes (11 to 13 rather than 14 to 16) and fewer spiral ribs (two to three rather than six) on the rest of the whorl. With future collecting, it is possible that *C.* new species? and *C. dilloni* may prove to be the same.

Campanile new species? superficially resembles *Campanile greenellum* Hanna and Hertlein (1939:100–102, figs. 1, 2) from early Paleocene ("Martinez Stage") strata near San Francisco, California. Specimens of *C.* new species? approximate the size of the upper portion of the holotype of *C. greenellum,* and in *C.* new species? the whorl profile is much straighter and the carina nodes are not as swollen nor as elongate anteriorly.

The history of the naming of *Campanile,* as well as the family Campanilidae, is complex. The type species of *Campanile,* furthermore, has been the subject of much debate. For an excellent summation of all these difficulties, the reader is referred to Houbrick (1981).

The name *Campanile* was used on the West Coast until Hanna and Hertlein (1949) used Iredale's (1917) *Campa-*

nilopa for *Campanilopa dilloni* Hanna and Hertlein. Houbrick (1981) pointed out that *Campanilopa* is a junior synonym of *Campanile*. Wenz (1940) also indicated this fact. Wrigley (1940) regarded the English Eocene *Campanile* species to be congeneric with the Recent species, *Campanile symbolicum*, and that sculptural differences do not justify a generic separation. Davies (1975) also did not recognize *Campanilopa* as a distinct taxon. Based on these above remarks and because, to date, no one has actually fully discussed or documented the morphologic details that are diagnostic of *Campanilopa*, the name *Campanilopa* is not used in this present report.

Superfamily Calyptraeacea

Family Calyptraeidae Blainville, 1824

Genus *Calyptraea* Lamarck, 1799

Type Species. By monotypy, *Patella chinensis* Linné, 1758.

Calyptraea diegoana (Conrad, 1855)

Figure 34

Trochita diegoana Conrad, 1855:7, 17; 1857:327, pl. 5, fig. 42.

Galerus excentricus Gabb, 1864:136, pl. 20, fig. 95; pl. 29, fig. 232a. Dickerson, 1913:264.

Calyptraea calabasaensis Nelson, 1925:419, pl. 54, figs. 8a–b.

Calyptraea (*Galerus*) *calabasaensis* Nelson. Clark and Woodford, 1927:120, pl. 21, figs. 10–13.

Calyptraea diegoana (Conrad). Stewart, 1927:340–341, pl. 27, fig. 15. Turner, 1938:89–90, pl. 20, figs. 1–2. Weaver, 1943:351–352, pl. 71, figs. 16, 20; pl. 103, fig. 3; 1953:29. Stewart, 1946:pl. 11, fig. 5. Kleinpell and Weaver, 1963: 186, pl. 24, fig. 7. Hickman, 1969:79, 82, pl. 11, figs. 7–8; 1980:33–34, pl. 2, figs. 18–21. Smith, 1975:469, table 2. Givens and Kennedy, 1979:table 2. Deméré, Sundberg, and Schram, 1979:pl. 2, fig. 7. Squires, 1984:21, fig. 6q.

Primary Type Material. USNM holotype 1856, Tejon? horizon, San Diego, California.

Molluscan Stage Range. "Martinez" through lower Oligocene.

Geographic Distribution. San Diego, California through Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 361, 364, 816, 827, 835, 838, 844, 845. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN localities 363, 828.

Remarks. At localities 361, 363, 816, 835, 838, and 844, only single specimens were found. At each of the localities 359, 364, 827, and 828, five to nine specimens were found. Specimens were most abundant at locality 358 where 15 were found, and they represent a partial growth series. At all localities except 827, specimens are unattached. At locality 827, one individual of *C. diegoana* is apparently attached to the carinate shoulder region on a specimen of *Clavilithes tabulatus*, and a second individual is atttached to another specimen of *C. diegoana*.

Genus *Crepidula* Lamarck, 1799

Type Species. By monotypy, *Patella fornicata* Linné.

Crepidula new species?

Figure 35

Crepidula new species. Squires, 1977:table 1.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 219.

Remarks. Only a single specimen was found, and it is a partial internal mold. The shell interior is filled with very hard matrix, and the septum cannot be exposed without destroying the shell.

The spire is moderately elevated and is just left of the center of the shell. The specimen may be a new species, but due to poor preservation a specific determination cannot be made at this time.

If this Whitaker Peak specimen is a new species, then it would be the earliest one on the West Coast. Previously, the earliest known species of *Crepidula* from the West Coast was *Crepidula* (*Spirocrypta*) *inornata* Dickerson (1916:489, pl. 38, figs. 5a, b) from the Domengine Formation ("Domengine Stage") near Coalinga, California. *Crepidula* new species? differs from it in the following features: larger, upper aperture margin is straight not curved, and the spire is much nearer the center of the shell. The only other described Eocene species of *Crepidula* from the West Coast is *C.* (*Spirocrypta*) *pileum* (Gabb, 1864:137, pl. 29, figs. 233, 233a, b; Anderson and Hanna, 1925:122, pl. 13, fig. 7; Stewart, 1927:341–342, pl. 29, figs. 2, 3; Clark, 1938:701, pl. 4, fig. 19; Turner, 1938: 90, pl. 20, fig. 6; Weaver, 1943:356, pl. 72, figs. 10, 16; pl. 103, fig. 15; Kleinpell and Weaver, 1963:186–187:pl. 24, figs. 8, 10, 11; Givens, 1974:71; Deméré, Sundberg, and Schram, (1979:table 1) from upper Eocene to lower Oligocene strata in California through Washington. Stewart (1927), Turner (1938), and Hoagland (1977) even considered *C.* (*S.*) *inornata* and *C.* (*S.*) *pileum* to be the same. *Crepidula* new species? differs from *C.* (*S.*) *pileum* in the following features: spire more elevated and nearer the central part of the shell.

Dickerson (1915:pl. 5, figs. 6a, b) illustrated *Crepidula* new species from Eocene strata in the San Emigdio Mountains, south-central California, but he did not describe or discuss the new species. *Crepidula* new species? from the Whitaker Peak area differs from Dickerson's new species in the following features: spire not marginal and the protoconch does not project beyond the margin of the shell.

Superfamily Strombacea

Family Strombidae Rafinesque, 1815

Genus *Ectinochilus* Cossmann, 1889

Type Species. By original designation, *Strombus canalis.*

Subgenus *Macilentos* Clark and Palmer, 1923

Type Species. By original designation, *Rimella macilenta* White, 1889.

Ectinochilus (*Macilentos*) *macilentus* (White, 1889)

Figure 36

Rimella macilenta White, 1889:19, pl. 3, figs. 10–12.

Ectinochilus (*Macilentos*) *macilentus* (White). Clark and Palmer, 1923:280, pl. 51, figs. 9–10. Givens, 1974:72, pl. 7, figs. 13, 16. Squires, 1977:table 1; 1983b:fig. 9b; 1984: 21–22, fig. 6s.

Rimella (*Macilentos*) *macilenta* White. Vokes, 1939:155–156, pl. 20, figs. 1–2, 4–5.

Ectinochilus macilentus (White). Stewart, 1946:93, pl. 11, figs. 12–15. Givens and Kennedy, 1979:83, table 1.

Primary Type Material. USNM holotype 20114, Domengine Formation, about 3 km north of New Idria, section 16, T 17 S, R 12 E, Priest Valley quadrangle, Fresno County, California; CAS paratype 769, Llajas Formation, CAS locality 393.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. San Diego through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 362, 807, 842. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN localities 363, 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 232, 237, 808.

Remarks. Fourteen specimens were found at localities 219 and 362 and preservation is good. Elsewhere, about eight specimens were found at each locality, and preservation is poor with internal molds common.

Genus *Chedevillia* Cossmann, 1906

Type Species. By original designation, *Rimella munieri* Chédeville, 1904a.

Chedevillia saltonensis Squires and Advocate, 1986

Figure 37

Chedevillia saltonensis Squires and Advocate, 1986:855–856, figs. 2.2–2.4.

Primary Type Material. UCLA holotype 28987, Maniobra Formation, CSUN locality 662.

Molluscan Stage Range. "Capay."

Geographic Distribution. Orocopia Mountains through Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 360, 830.

Remarks. One specimen was found at locality 360, and two were found at locality 830. Preservation is poor. The specimens show the flange that extends along the right margin of the shell and the characteristic intricate cancellate sculpture pattern on the surface of the shell. In the interspaces between the primary spiral ribs, there are three fine spiral ribs. Another characteristic feature present is a noded, angulate shoulder on the apertural half of the body whorl. The nodes on the Whitaker Peak specimens are larger than those on the holotype and slightly elongate.

The presence of *C. saltonensis* in the Whitaker Peak area is the first report of this species outside of the type area in the Maniobra Formation in the Orocopia Mountains, Riverside County, southern California.

Family Seraphsidae Jung, 1974

Genus *Paraseraphs* Jung, 1974

Type Species. By original designation, *Paraseraphs tetanus* Jung, 1974 [=*Terebellum fusiforme* of authors, not of Lamarck].

Paraseraphs erraticus (Cooper, 1894)

Figure 38

Tornatina erratica Cooper, 1894:47, pl. 2, fig. 35, Waring, 1917:pl. 15, fig. 11.

Terebellum californicum Vokes, 1939:157, pl. 20, figs. 7–8, 11.

Terebellum (*Terebellum*) *erraticum* (Cooper). Kleinpell and Weaver, 1963:189, pl. 25, figs. 8–9.

Paraseraphs erraticus (Cooper). Jung, 1974:41, pl. 12, figs. 8–14; pl. 13, figs. 1–3. Givens and Kennedy, 1979:87, tables 1, 3. Squires, 1984:23, fig. 7a.

Primary Type Material. CAS holotype 608, Eocene strata, Rose Canyon, San Diego, California.

Molluscan Stage Range. "Capay" through "Transition."

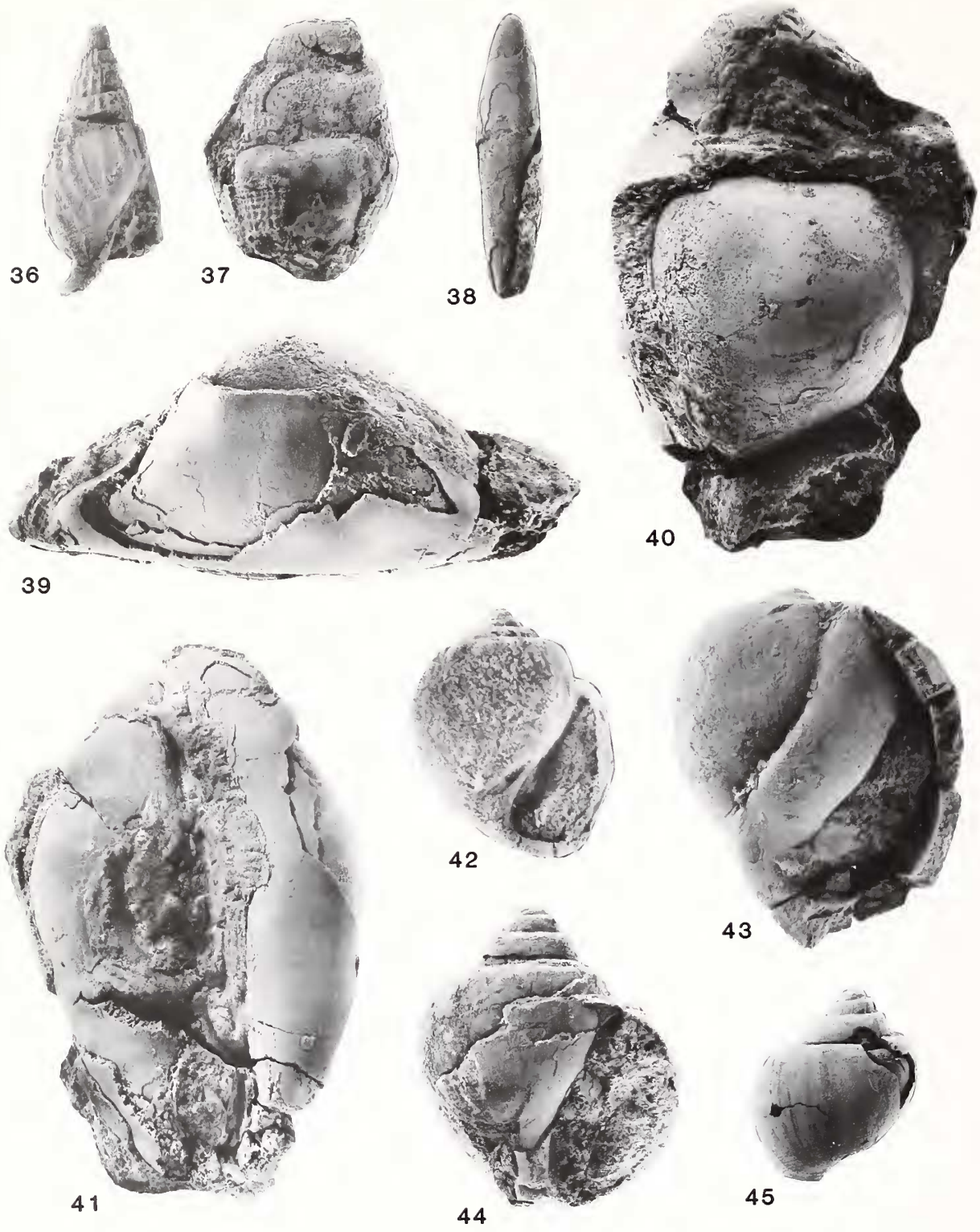
Geographic Distribution. San Diego through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 362, 825, 830, 851.

Remarks. Six specimens were found at locality 362, and single specimens were found at each of the other localities. Preservation is generally fair, but the outer lip area has been broken off in all specimens. In addition, details of the inner lip and posterior canal areas are obscured due to preservation.

The presence of *P. erraticus* in the *Turritella uvasana infera* fauna of the Whitaker Peak section extends the molluscan stage range of this species into the "Capay Stage" proper. Previously, the lower range limit had been known to be uppermost "Capay" (Squires, 1984).

According to Jung (1974), *Paraseraphs* appeared during the early Eocene in France and Italy and reached California in the middle Eocene. Due to the presence of this taxon in the "Capay Stage" portion of the Juncal Formation, Whit-



Figures 36–45. Whitaker Peak area Eocene mesogastropods. Unless otherwise indicated, views are apertural. **36.** *Ectinochilus* (*Macilentos*) *macilentus* (White, 1889), ×1.8, height 25 mm, width 11 mm, LACMIP hypotype 7463, CSUN loc. 237. **37.** *Chedevillia saltonensis* Squires and Advocate, 1986, abapertural view, ×2, height 23 mm, width 16 mm, LACMIP hypotype 7464, CSUN loc. 830. **38.** *Paraseraphs erraticus* (Cooper, 1894), ×1.8, height 27 mm, width 6 mm, LACMIP hypotype 7465, CSUN loc. 362. **39–41.** *Gisortia* new species? All parts ×0.75, height 122 mm, width 75 mm, LACMIP hypotype 7466, CSUN loc. 848. **39.** Side view, thickness 51 mm. **40.** Abapertural view, mostly internal mold. **42.** *Crommium pinyonensis* (Dickerson, 1914), ×2.5, height 17 mm, width 13 mm, LACMIP 7467, CSUN loc. 802. **43.**

aker Peak area, the arrival of this gastropod in California can now be pushed back to the early Eocene.

Superfamily Cypraeacea

Family Cypraeidae Gray, 1824

Subfamily Bernayinae Schilder, 1927

Genus *Gisortia* Jousseaume, 1884a

Type Species. By subsequent designation (Jousseaume, 1884b), *Ovula gisortina* Passy.

Gisortia clarki Ingram, 1940

Figures 39–41

Gisortia new species Clark and Vokes, 1936:877, pl. 2, figs. 1, 3.

Gisortia clarki Ingram, 1940:376–377, fig. 1; 1942:19, pl. 4, fig. 1; 1947:63–64, pl. 3, fig. 1.

Primary Type Material. UCMP holotype 14844, lower Llajas Formation, UCMP locality 4052 (see comment below).

Molluscan Stage Range. "Capay."

Geographic Distribution. Simi Valley area, southern California, through southern San Joaquin Valley, south-central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 807?, 837, 848.

Remarks. Only one complete specimen was found. It is from locality 848 and is a large individual that measures 122 mm in height and 75 mm in diameter. Most of the dorsal shell convexity (thickness) is represented by an external mold. This convexity is 51 mm high (above the flat shell venter) where it reaches its maximum at the midpoint of the dorsum. The spire is obscured by matrix. The narrow aperture curves to the left posteriorly and to a much lesser degree anteriorly. Several small teeth are present on the outer lip in the anterior half of the aperture (rest of aperture filled with matrix). At locality 837, only a poorly preserved outer lip (height 90 mm) was found.

The holotype is seemingly wider ventrally and more swollen dorsally when compared to the Whitaker Peak specimen, but the apparent differences are due to the better preservation of the holotype.

The type locality (UCMP locality 4052) given by Clark and Vokes (1936) and Ingram (1940, 1942, 1947) is generally described as in the "Capay Stage" portion of the Llajas Formation. In the UCMP official files on localities, however, this locality is assigned to the Pliocene Pico Formation in the Santa Clarita River Valley north of Simi Valley, California. Details as to the exact location of the type locality of *G. clarki,* therefore, are lacking.

A small internal mold specimen of *Gisortia* sp. cf. *G. clarki* Ingram, reported by Smith (1975:pl. 2, figs. 9, 13) from the late Paleocene ("Martinez Stage") basal Lodo Formation in central California is too poorly preserved to allow positive assignment to *G. clarki.*

Classification of *Gisortia* in this present report follows that of Schilder (1967).

Superfamily Naticacea

Family Naticidae Forbes, 1838

Subfamily Ampullospirinae Cox, 1930

Genus *Crommium* Cossmann, 1888

Type Species. By original designation, *Ampullaria willemetii* Deshayes, 1825.

Crommium pinyonensis (Dickerson, 1914)

Figure 42

Natica pinyonensis Dickerson, 1914a:295 [*nomen nudum*]; 1914b:302, pl. 29, figs. 5a–b.

"*Polinices*" sp. cf. "*P.*" *pinyonensis* (Dickerson). Smith, 1975: 469, pl. 2, figs. 22–23.

Crommium pinyonensis (Dickerson). Marincovich, 1977:227–228, pl. 18, figs. 8, 11–13 [not figs. 9–10 = *Ampullella* (*Ampullella*) *schencki* Vokes, 1939].

Primary Type Material. UCMP holotype 11761, UCMP paratype 11760, so-called Martinez Formation, at Shoemaker, Rock Creek quadrangle, Los Angeles County, California.

Molluscan Stage Range. Upper Paleocene through "Domengine."

Geographic Distribution. Simi Valley, southern California through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 364, 802, 823, 831?, 832, 833, 845, 846.

Remarks. This naticid is fairly common in the *Turritella uvasana infera* fauna. At most localities where it is present, there are fewer than five specimens. At localities 832 and 833, 20 specimens each were found, and at locality 802 about 100 specimens were collected. At localities 802, 832, and 833, the specimens occur in several closely spaced, thin-bedded channel-fill deposits that are extremely rich in *Crommium pinyonensis* and *Eocernina hannibali.*

This species is distinguished by its narrow umbilical opening, which may be closed in some specimens. Marincovich (1977:227, pl. 18, figs. 8, 11–13) described the parietal callus of *Crommium pinyonensis* as having an anterior lobe that slightly overhangs the umbilicus. This is evident, however, only on the illustrated specimens (Marincovich, 1977:pl. 18, figs. 9, 10) of *Ampullella* (*Ampullella*) *schencki.* The inner lip is also reflected along its entire length in *A.* (*A.*) *schencki,*

←

Eocernina hannibali (Dickerson, 1914), ×0.9, height 67 mm, width 50 mm, LACMIP hypotype 7468, CSUN loc. 237. **44.** *Pachycrommium clarki* (Stewart, 1927), ×1, height 51 mm, width 40 mm, LACMIP hypotype 7469, CSUN loc. 358. **45.** *Amaurellina caleocia* Vokes, 1939, side view, ×2, height 15 mm, width 12.5 mm, LACMIP hypotype 7470, CSUN loc. 219.

whereas in typical *Crommium* only the anterior end is reflected.

Genus *Eocernina* Gardner and Bowles, 1934

Type Species. By original designation, *Natica hannibali* Dickerson, 1914c.

Eocernina hannibali (Dickerson, 1914)

Figure 43

Natica hannibali Dickerson, 1914c:119, pl. 12, figs. 5a–b; 1916:508, pl. 38, figs. 9a–b.

Natica (*Cryptonatica*) *hannibali* Dickerson. Waring, 1917: pl. 15, figs. 21–23.

Ampullina hannibali (Dickerson). Hanna, 1927:306, pl. 48, figs. 1–3, 10.

Ampullina (*Globularia*) *hannibali* (Dickerson). Clark, 1929: pl. 11, fig. 12.

Cernina (*Eocernina*) *hannibali* (Dickerson). Turner, 1938: 87–88, pl. 19, fig. 3. Vokes, 1939:172, pl. 22, figs. 1, 3. Weaver, 1943:348–349, pl. 71, figs. 8–9, 21, 23.

Eocernina hannibali (Dickerson). Hanna and Hertlein, 1941: fig. 62-17. Marincovich, 1977:229–231, pl. 18, fig. 14; pl. 19, figs. 1–4. Givens and Kennedy, 1979:87, tables 1, 3. Squires, 1983b:fig. 9c; 1984:24, fig. 7c.

Globularia (*Eocernina*) *hannibali* (Dickerson). Stewart, 1946: pl. 11, fig. 18. Givens, 1974:75, pl. 9, figs. 1, 3. Squires, 1977:table 1.

Primary Type Material. CAS holotype 243, Umpqua Formation, CAS locality 25.

Molluscan Stage Range. "Capay" through "Transition."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 360, 361, 364?, 802, 803?, 807, 810?, 812, 814, 818?, 823, 824, 826, 827, 830, 831, 832, 833, 835,?, 837, 844, 845, 850. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219?, 232, 237, 809?

Remarks. *Eocernina hannibali* is a pervasive species in the Juncal Formation, especially in the *Turritella uvasana infera* fauna. At most localities less than six specimens were found. At localities 358, 827, 837, 845, and 850 about 20 specimens each were found. Growth series are present at localities 237, 827, 837, 845, and 850. The largest specimens (up to 78 mm height) were found at locality 837. At localities 802 and 833, the specimens occur in several closely spaced, thin-bedded channel-fill deposits that are extremely rich in *E. hannibali* and *Crommium pinyonensis*.

Genus *Pachycrommium* Woodring, 1928

Type Species. By original designation, *Amaura guppyi* Gabb, 1873.

Pachycrommium clarki (Stewart, 1927)

Figure 44

Amauropsis alveata (Conrad). Arnold, 1910:pl. 4, fig. 21. Dickerson, 1915:pl. 5, fig. 9. Waring, 1917:pl. 15, fig. 25. [Misidentifications.]

Amaurellina (*Euspirocrommium*) *clarki* Stewart, 1927:336–339, pl. 26, figs. 8–9 [new name, in part, for *Amauropsis alveata* (Conrad, 1855), preoccupied and misidentified]. Clark, 1929:pl. 11, fig. 10. Turner, 1938:86, pl. 20, fig. 3. Weaver, 1943:345, pl. 70, figs. 10, 18. Kleinpell and Weaver, 1963:188, pl. 27, fig. 15.

Amaurellina clarki Stewart. Gardner and Bowles, 1934:246, figs. 6, 8.

Amaurellina? multiangulata Vokes, 1939:174, pl. 22, figs. 2, 8, 13.

Pachycrommium? clarki (Stewart). Vokes, 1939:175, pl. 22, figs. 11, 30. Givens, 1974:73, pl. 8, figs. 6, 10. Squires, 1977:table 1.

Amaurellina (*Euspirocrommium?*) *clarki* Stewart. Stewart, 1946:pl. 11, fig. 3.

Pachycrommium clarki (Stewart). Marincovich, 1977:238–241, pl. 20, figs. 4–10. Squires, 1983b:fig. 9b; 1984:25, fig. 7e.

Primary Type Material. UCMP holotype 31385, UCMP paratype 31386 of *Amaurellina* (*Euspirocrommium*) *clarki* Stewart, Llajas Formation, UCMP locality 7004.

Molluscan Stage Range. "Capay" through "Tejon."

Geographic Distribution. San Diego, California through northern Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 803?, 829, 830, 841?. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 232, 237, 808?.

Remarks. At most localities, there are only a few poorly preserved fragmentary specimens. Best preservation is at locality 358 where six large specimens were found. About 12 specimens were found at localities 219 and 237, and these specimens represent a partial growth series.

This large species with a high spire is characterized by strong tabulation on the body and penultimate whorls. This tabulation becomes progressively less toward the apex.

The earliest name used for this species, *Amauropsis alveata* (Conrad), was based on *Natica alveata* Conrad, 1855, which is a homonym of *N. alveata* Troschel, 1852. Early workers mistakenly used the name *Amauropsis alveata* (Conrad) to refer to three different species, now referred to as *Tejonia moragai* (Stewart), *Pachycrommium clarki* (Stewart), and *Amaurellina caleocia* Vokes (Marincovich, 1977).

Genus *Amaurellina* Fischer, 1885

Type Species. By monotypy, *Ampullaria spirata* Lamarck, 1804.

Amaurellina caleocia Vokes, 1939

Figure 45

Amauropsis alveata (Conrad). Dickerson, 1916:pl. 38, fig. 7. [Misidentification.]

Amaurellina caleocia Vokes, 1939:172–173, pl. 22, figs. 4–6 [new name, in part, for *Amauropsis alveata* (Conrad) of Dickerson, 1916, preoccupied and misidentified]. Marincovich, 1977:241–243, pl. 20, figs. 11–13; pl. 21, figs. 1–2. Kappeler, Squires, and Fritsche, 1984:table 2.

Amaurellina garzaensis Vokes, 1939:173, pl. 22, figs. 9, 12, 16. Marincovich, 1977:241, pl. 20, fig. 13.

Primary Type Material. UCMP holotype 33781, UCMP paratype 15862 of *Amaurellina caleocia* Vokes, Domengine Formation, UCMP locality 672.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Orocopia Mountains, southern California through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 361, 827, 842, 845. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 232.

Remarks. Only a few specimens were found at each locality, except at locality 361 where 15 specimens were found. This species is characterized by the elevated spire and presence of minute spiral sculpture on the body whorl. Previously, this species has not been reported specifically as ranging into the "Capay Stage."

See "Remarks" under *Pachycrommium clarki* for a discussion of the early nomenclatural history of this species.

Subfamily Polinicinae Finlay and Marwick, 1937

Genus *Polinices* Montfort, 1810

Type Species. By subsequent designation, *Polinices albus* Montfort, 1810.

Subgenus (*Euspira*) Agassiz *in* J. Sowerby, 1838

Type Species. By subsequent designation (Harris, 1897), *Ampullaria sigaretina* Lamarck, 1804.

Polinices (*Euspira*) *nuciformis* (Gabb, 1864)

Figure 46

Lunatia nuciformis Gabb, 1864:107, pl. 28, fig. 218. Dickerson, 1916:pl. 39, fig. 4.

Lunatia cowlitzensis Dickerson, 1915:57, pl. 4, figs. 12a–b.

Natica nuciformis (Gabb). Anderson and Hanna, 1925:116, pl. 10, fig. 8.

Polinices (*Euspira*) *nuciformis* (Gabb). Clark and Woodford, 1927:121, pl. 21, figs. 16–17. Turner, 1938:88, pl. 20, figs. 4–5. Clark, 1938:703–704, pl. 4, figs. 26, 31. Vokes, 1939:168, pl. 21, figs. 12–14. Weaver, 1943:342–343, pl. 70, figs. 1–2; pl. 103, fig. 2. Hickman, 1980:37–38, pl. 4, fig. 8.

Euspira nuciformis (Gabb). Stewart, 1927:323–324, pl. 30, fig. 16; 1946:pl. 11, fig. 16. Weaver, 1953:29. Givens, 1974:77, pl. 7, fig. 14. Squires, 1977:table 1.

Polinices (*Euspira*) *nuciformis* var. *cowlitzensis* (Dickerson). Weaver, 1943:343, pl. 69, figs. 10–11, 13–19.

Polinices (*Euspira*) *nuciformis* (Gabb). Marincovich, 1977:281–285, pl. 26, figs. 6–9. Squires, 1984:25, fig. 7f.

Primary Type Material. ANSP lectotype 4213, designated by Stewart (1927:323), Tejon Formation, Live Oak Canyon, Kern County, California.

Molluscan Stage Range. Upper Paleocene through "Tejon."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 237.

Remarks. A single specimen was found at locality 219, and five specimens were found at locality 237. The globose specimens show the characteristic open umbilicus.

Genus *Neverita* Risso, 1826

Type Species. By monotypy, *Neverita josephina* Risso, 1826.

Subgenus *Neverita* s.s.

Neverita (*Neverita*) *globosa* Gabb, 1869

Figure 47

Neverita globosa Gabb, 1869:161, pl. 27, fig. 39. Dickerson, 1916:510, pl. 39, figs. 5a–b. Stewart, 1927:326–327, pl. 28, fig. 6. Clark and Woodford, 1927:121–122, pl. 22, figs. 5–10. Turner, 1938:89, pl. 19, figs. 6–7, 13–15. Vokes, 1939:169, pl. 21, figs. 9, 15–19. Givens and Kennedy, 1979:tables 1–3.

Neverita weaveri Dickerson, 1915:57, pl. 4, figs. 10a–b.

Neverita nomlandi Dickerson, 1917b:173–174, pl. 30, figs. 2a–b.

Polinices weaveri (Dickerson). Turner, 1938:86, pl. 20, figs. 14, 16.

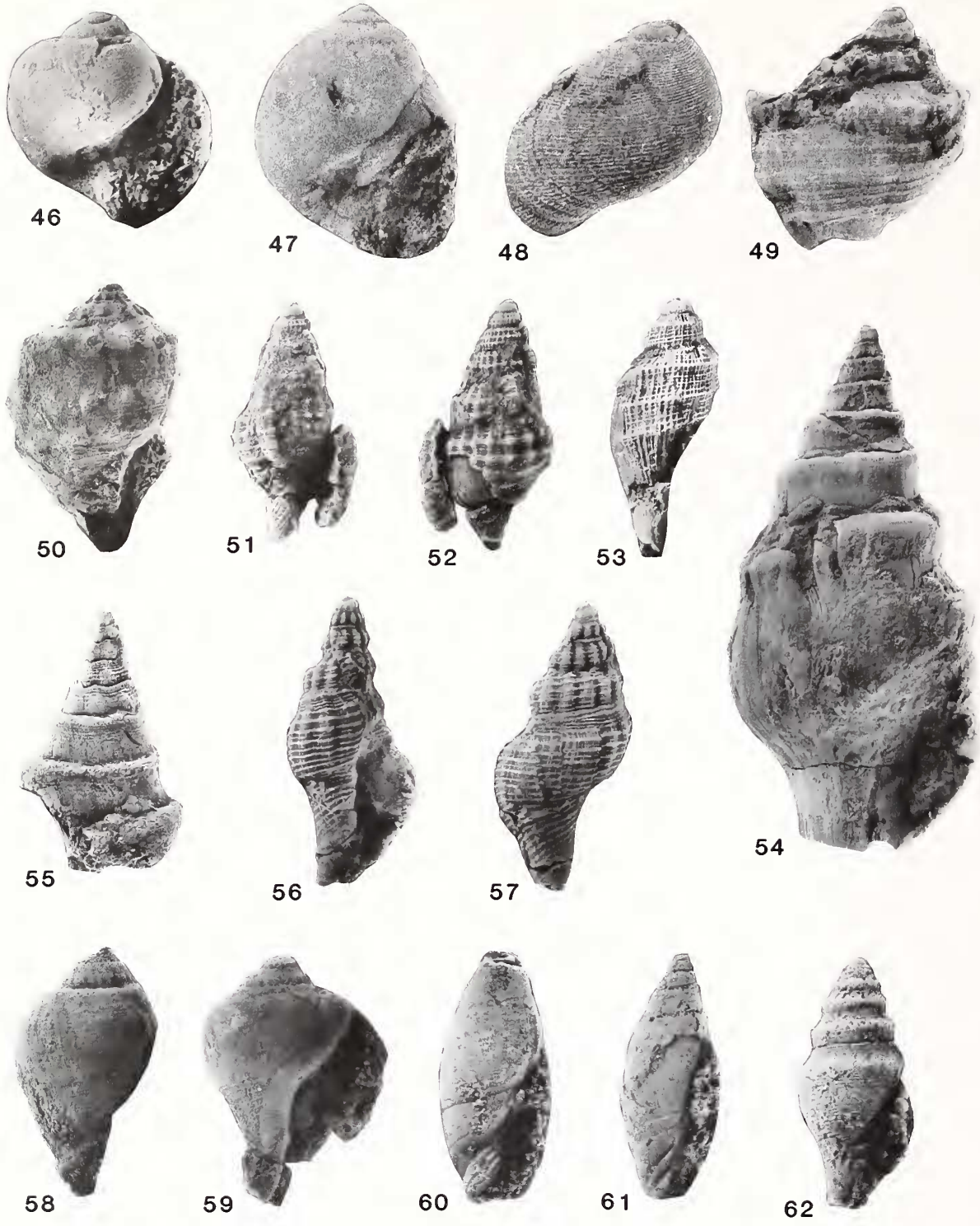
Neverita globosa reefensis Vokes, 1939:169, pl. 21, figs. 24–25.

Polinices (*Neverita*) *globosa* (Gabb). Weaver, 1943:339, pl. 68, figs. 21, 24; pl. 69, figs. 5–6; pl. 100, fig. 29.

Polinices (*Neverita*) *weaveri* (Dickerson). Weaver, 1943:340, pl. 68, figs. 16–17; pl. 69, fig. 3.

Polinices (*Neverita*) *nomlandi* (Dickerson). Weaver, 1943:340, pl. 69, figs. 8–9, 12.

Neverita (*Neverita*) *globosa* Gabb. Givens, 1974:76. Marincovich, 1977:312–316, pl. 28, figs. 10–15; pl. 29, figs. 1–3. Squires, 1984:25, fig. 7g.



Figures 46–62. Whitaker Peak area Eocene mesogastropods and neogastropods. Unless otherwise noted, views are apertural. **Figs. 46–53.** Mesogastropods. **46.** *Polinices* (*Euspira*) *nuciformis* Gabb, 1869, ×4, height 9 mm, width 8 mm, LACMIP hypotype 7471, CSUN loc. 219. **47.** *Neverita* (*Neverita*) *globosa* Gabb, 1869, ×3.1, height 13 mm, width 10 mm, LACMIP hypotype 7472, CSUN loc. 827. **48.** *Sinum obliquum* (Gabb, 1864), abapertural view, ×2.5, height 14.5 mm, width 14 mm, LACMIP hypotype 7473, CSUN loc. 237. **49.** *Galeodea* (*Gomphopages*) *meganosensis* Vokes, 1939, abapertural view, ×2.7, height 15 mm, width 13 mm, LACMIP hypotype 7474, CSUN loc. 845. **50.** *Phalium* (*Semicassis*) *tuberculiformis* (Hanna, 1924), internal mold, side view, ×1.5, height 29 mm, width 17 mm, LACMIP hypotype 7475, CSUN loc. 219. **51–52.** *Sassia bilineata* (Dickerson, 1916). All parts ×2.5, height 15.5 mm, width 8 mm, LACMIP hypotype 7476, CSUN loc. 802.

Neverita (*Glossaulax*?) *globosa* Gabb. Givens and Kennedy, 1976:965–966, pl. 2, figs. 5–14, 16, 18–19.

Primary Type Material. MCZ holotype 27859, Domengine? Formation, 16 km west of Griswold's, on the road from San Juan to New Idria, and southeast of the "Sheep Well," T 15 S, R 9 E, Priest Valley quadrangle, San Benito County, California.

Molluscan Stage Range. "Meganos" through upper Eocene.

Geographic Distribution. San Diego, California through western Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN loealities 358, 802, 827, 845.

Remarks. At all of the localities except 358 (where only one specimen was found), six to nine specimens were found. At locality 845, a growth series was found with specimens ranging in height from 5 to 18 mm. The larger specimens are more elongate than the more globose smaller specimens. Preservation of the distinctive, heavy parietal callus is excellent in all the Whitaker Peak specimens.

Subfamily Sininae Wenz, 1941

Genus *Sinum* Röding, 1798

Type Species. By subsequent designation (Dall, 1915), *Helix haliotoidea* Linné, 1758.

Sinum obliquum (Gabb, 1864)

Figure 48

Naticina obliqua Gabb, 1864:109, pl. 21, fig. 112. Dickerson 1915:pl. 5, figs. 5a–b.

Sinum occidentis Weaver and Palmer, 1922:32–33, pl. 11, figs. 8, 26. Weaver, 1943:351, pl. 71, fig. 15.

Sinum coryliforme Anderson and Hanna, 1925:120, pl. 9, fig. 10; pl. 10, fig. 15; pl. 15, fig. 8.

Sinum obliquum (Gabb). Stewart, 1927:327, pl. 30, fig. 7a. Clark, 1938:704, pl. 3, figs. 32, 37. Weaver, 1943:350–351, pl. 71, fig. 13; pl. 103, fig. 6. Moore, 1968:28, pl. 12d. Hickman, 1969:85–88, pl. 11, figs. 9–10; 1980:40–41, pl. 4, figs. 12–13. Marincovich, 1977:347–350, pl. 33, figs. 1–12. Squires, 1977:table 1; 1984:26, fig. 7h. Givens and Kennedy, 1979:table 4.

Primary Type Material. ANSP lectotype 4215, designated by Stewart (1927:327), Tejon Formation, Fort Tejon area, Kern County, California.

Molluscan Stage Range. "Capay" through lower Oligocene.

Geographic Distribution. San Diego, California through southwestern Washington.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Only three specimens were found. Preservation is good, and the distinctive spiral sculpture is well preserved.

Superfamily Tonnacea

Family Cassidae Swainson, 1832

Genus *Galeodea* Link, 1807

Type Species. By monotypy, *Buccinum echinophorum* Linné, 1758.

Subgenus *Gomphopages* Gardner, 1939

Type Species. By original designation, *Galeodea turneri* Gardner, 1939.

Galeodea (*Gomphopages*) *meganosensis* Vokes, 1939

Figure 49

Galeodea sutterensis Dickerson. Clark and Woodford, 1927: 113, pl. 19, fig. 21. [Misidentification *fide* Vokes, 1939.]

Galeodea sutterensis meganosensis Vokes, 1939:151–152, pl. 19, fig. 18.

Galeodea (*Gomphopages*) *meganosensis* Durham, 1942b:184.

Primary Type Material. UCMP holotype 31244, Meganos Formation, UCMP locality 3152.

Molluscan Stage Range. "Meganos" through "Capay."

Geographic Distribution. Whitaker Peak area, southern California through Mount Diablo, west-central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 362, 816, 827, 845.

Remarks. Seven specimens representing a growth series were found at locality 827. At the other localities, only one or two specimens were found. Preservation is fair to good.

This species is characterized by two carinae on the body whorl, 11 to 12 swollen spines on the carina on the shoulder, and fine unnoded spiral ribs covering the shell. On the holotype there is also a fairly prominent unnoded spiral rib between the carinae as well as another unnoded spiral rib

---

←

52. Abapertural view. **53.** *Ficopsis remondii crescentensis* Weaver and Palmer, 1922, ×2.5, height 17 mm, width 6.5 mm, LACMIP hypotype 7477, CSUN loc. 845. **Figs. 54–62.** Neogastropods. **54–55.** *Clavilithes tabulatus* (Dickerson, 1913). All parts CSUN loc. 827. **54.** ×1, height, 85 mm, width 38 mm, LACMIP hypotype 7478. **55.** Upper spire, ×1.5, height 28 mm, width 17 mm, LACMIP hypotype 7479. **56–57.** *Streptochetus californiana* new species. All parts ×2.5, height 19 mm, width 8 mm, LACMIP holotype 7480, CSUN loc. 845. **57.** Abapertural view. **58.** *Pseudoliva dilleri* Dickerson, 1914, ×1.2, height 32 mm, width 19 mm, LACMIP hypotype 7481, CSUN loc. 359. **59.** *Strepsidura ficus* (Gabb, 1864), ×1.8, height 23 mm, width 16 mm, LACMIP hypotype 7482, CSUN loc. 360. **60.** *Ancilla gabbi* Cossmann, 1899, ×3.5, height 11.5 mm, width 4.5 mm, LACMIP hypotype 7483, CSUN loc. 237. **61.** *Olivella mathewsonii* Gabb, 1864, ×3.4, height 11.5, width 4.5 mm, LACMIP hypotype 7484, CSUN loc. 237. **62.** *Proximitra*? *cretacea* Gabb, 1864, ×4, height 10 mm, width 4.5 mm, LACMIP 7485, CSUN loc. 237.

just anterior to the anteriormost carina. A similar sculpture pattern is also present on the Whitaker Peak specimens.

Previously, this species has not been reported as ranging into the "Capay Stage" or as occurring as far south as the Whitaker Peak area.

Genus *Phalium* Link, 1807

Type Species. By subsequent designation (Dall, 1909), *Buccinum glaucum* Linné, 1758.

Subgenus *Semicassis* Mörch, 1852

Type Species. By subsequent designation (Harris, 1897), *Cassis japonica.*

Phalium (*Semicassis*) *tuberculiformis* (Hanna, 1924)

Figure 50

Morio (*Sconsia*) *tuberculatus* Gabb, 1864:104, pl. 19, fig. 57. Arnold, 1907:pl. 39, fig. 9.

Not *Cassidaria tuberculata* Risso, 1826:186.

Morio tuberculatus Gabb. Dickerson, 1913:264.

Galeodea tuberculata (Gabb). Dickerson, 1916:pl. 42, fig. 2.

Galeodea (*Morio*) *tuberculata* (Gabb). Waring, 1917:pl. 15, fig. 17.

Galeodea tuberculiformis Hanna, 1924:167 [new name for *Morio* (*Sconsia*) *tuberculatus* Gabb, 1864, preoccupied]. Schenck, 1926:83–84, pl. 14, figs. 12–16. Stewart, 1927: 380–381, pl. 28, fig. 11. Vokes, 1939:149–150, pl. 19, figs. 19, 21, 23–27.

Coalingodea tuberculiformis (Hanna). Durham, 1942b:186, pl. 29, figs. 5, 9. Givens, 1974:78–79, pl. 8, fig. 7. Squires, 1977:table 1.

Cassis (*Coalingodea*) *tuberculata* (Gabb). Abbott, 1968:59–60, pl. 34.

Phalium (*Semicassis*) *tuberculiformis* (Hanna). Givens and Kennedy, 1979:82, 95, tables 1, 3. Squires, 1984:27, fig. 71.

Primary Type Material. ANSP lectotype 4343 of *Morio* (*Sconsia*) *tuberculatus* Gabb and *Galeodea tuberculiformis* Hanna, designated by Stewart (1927:381), Tejon? Formation, Martinez, California.

Molluscan Stage Range. "Capay"?, "Domengine" through "Transition."

Geographic Distribution. San Diego, southern California, through central California.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 219.

Remarks. Two early adult specimens (height 29 mm) were found at locality 828. One has a thickened outer lip and a varix, and both have the beaded sculpture covering the shell surface. Such features are characteristic of *P.* (*S.*) *tuberculiformis.* Two specimens were also found at locality 291, but both are internal molds.

Abbott (1968) provisionally regarded *Galeodea tuberculata* var. *crescentensis* Weaver and Palmer (1922:37–38, pl. 11, figs. 18, 20), from northwestern Washington, as a synonym of *Phalium* (*Semicassis*) *tuberculiformis.* Weaver (1943: 403), however, assigned this variety to *Galeodea crescentensis* Weaver and Palmer.

Family Ranellidae Gray, 1854

Subfamily Cymatiinae Iredale, 1913

Genus *Sassia* Bellardi, 1872

Type Species. By original designation, *Triton apenninica* Sassi.

Sassia bilineata (Dickerson, 1916)

Figures 51, 52

Fasciolaria bilineata Dickerson, 1916:493, pl. 37, figs. 6a–b. Hanna, 1927:319.

Sassia bilineata (Dickerson). Turner, 1938:91, pl. 18, fig. 20. Weaver, 1943:416, pl. 82, figs. 8, 11–12, 15. Givens, 1974: 79–80, pl. 11, figs. 8, 10. Givens and Kennedy, 1979:tables 1, 3.

Cymatium (*Septa*) *janetae* Squires, 1983a:355–357, fig. 2d. [Misidentification, in part.]

Primary Type Material. UCMP holotype 11834, UCMP paratype 11835, Ardath Shale, UCMP locality 2226.

Molluscan Stage Range. "Capay" through "Transition."

Geographic Distribution. San Diego, southern California, through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 802?, 845.

Remarks. Two upper spire specimens were found and preservation is poor. This species is characterized by angulate whorls with cancellate sculpture and usually about one varix per whorl. A ramp area is present on the penultimate and body whorls.

UCLA paratype 59193, designated as an immature specimen of *Cymatium* (*Septa*) *janetae* from the Llajas Formation, Simi Valley, California, is instead *Sassia bilineata.* Givens (1986, pers. commun.) has collected well-preserved specimens of *S. bilineata* from the Ardath Shale, San Diego, California, that show the same ornamentation as UCLA paratype 59193. After examining my own recently collected specimens of *S. bilineata* from the Ardath Shale, at UCR locality 4847, I agree with Givens' observation.

Sassia formerly was assigned to family Cymatiidae, but Beu (1986) has shown that the Cymatiidae should be referred to as family Ranellidae because of priority in naming.

Family Ficidae Conrad, 1867

Genus *Ficopsis* Conrad, 1866

Type Species. By subsequent designation (Stewart, 1927), *Hemifusus remondii* Gabb, 1864.

Ficopsis remondii crescentensis Weaver and Palmer, 1922

Figure 53

Ficopsis angulatus Weaver, 1905:119, pl. 13, fig. 5.
Not *Pyrula angulata* Edwards, 1866:pl. 4.
Ficopsis remondii (Gabb) var. *crescentensis* Weaver and Palmer, 1922:39–40, pl. 11, fig. 14 [new name for *Ficopsis angulatus* Weaver, 1905, preoccupied]. Stewart, 1930:40–41. Turner, 1938:93, pl. 15, fig. 19. Weaver, 1943:399, pl. 77, fig. 10.
Ficopsis remondii crescentensis Weaver and Palmer. Vokes, 1939:152–153. Givens, 1974:82, pl. 9, fig. 11. Squires, 1977:table 1. Givens and Kennedy, 1979:87, tables 1, 3.
Ficopsis crescentensis Weaver and Palmer. Stewart, 1946:pl. 11, fig. 17.
Ficopsis remondi crescentensis Weaver and Palmer. Moore, 1968:26, pl. 11c.

Primary Type Material. UCMP holotype 11887 of *Ficopsis angulatus* Weaver, Eocene strata, UCMP locality 337. UW holotype 205 (CAS 7616) of *Ficopsis remondii crescentensis* Weaver and Palmer, Crescent Formation?, UW locality 358.

Molluscan Stage Range. "Capay" through "Transition."

Geographic Distribution. San Diego, California through northwestern Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 361, 362, 827, 845. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 363. *Turritella uvasana appinae* fauna, Matilija Sandstone?: CSUN localities 219, 232, 237.

Remarks. At locality 237, six specimens were found, and they represent a partial growth series, ranging in height from 9 to 28 mm. Only a few specimens (less than four) were found at each of the other localities. Preservation is mostly good. All show the characteristic cancellate sculpture and the presence of three prominent carinae on the body whorl.

Order Neogastropoda

Superfamily Buccinacea

Family Fasciolariidae Gray, 1853

Genus *Clavilithes* Swainson, 1840

Type Species. By subsequent designation (Grabau, 1904), *Fusus parisiensis* Mayer-Eymar, 1877 [=*Fusus longaevus* Lamarck, 1803, not Solander, 1766].

Clavilithes tabulatus (Dickerson, 1913)

Figures 54, 55

Clavella tabulata Dickerson, 1913:283, pl. 12, fig. 7.
Clavilithes tabulatus (Dickerson). Clark and Vokes, 1936: 874, pl. 1, fig. 3. Givens, 1974:85, pl. 10, figs. 4–5. Squires, 1984:31, fig. 8g.
Clavilithes new species Clark and Vokes, 1936:874, pl. 1, fig. 1. Givens and Kennedy, 1976:973, pl. 4, figs. 9, 12.
Clavilithes cf. *C. tabulatus* (Dickerson). Crowell and Susuki, 1959:588–589, pl. 2, figs. 6–7.
Clavilithes new species Clark and Vokes. Squires, 1984:31, fig. 8h.

Primary Type Material. UCMP holotype 11753, Capay Formation, UCMP locality 1853.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Orocopia Mountains, southern California through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 361, 364, 802, 807, 826, 827, 830, 831, 832, 833, 834, 837.

Remarks. *Clavilithes tabulatus* is a fairly common and locally abundant species in the *Turritella uvasana infera* fauna between Sharps Canyon and Canton Canyon. At most localities there are only a few specimens (one to four), but at localities 364 and 827, 10 and 28 specimens were found, respectively. Preservation is good at all localities, especially at locality 827. In almost every specimen, however, the long anterior canal has been broken off.

At locality 827 there is a nearly complete growth series with specimens ranging in height from 28 to 83 mm. Five of the specimens, and Figure 55 is one of them, have collabral costae (seven per whorl) in the uppermost five or six whorls of the spire. The remaining larger whorls (as many as five) have no collabral sculpture. Similarly, at localities 359, 364, and 837, there are some specimens that have collabral costae only on the upper spire whorls. At all the localities in which *C. tabulatus* was collected, those specimens that have the collabral costae are those in which the uppermost spires are present and well preserved.

Most of the specimens of *C. tabulatus* in the Whitaker Peak section also have fine to moderately strong spiral ribs (usually five) anterior to the tabulate shoulder on the spire whorls. These ribs are not present on the body whorl, and, in some cases, are not on the penultimate whorl. On most of the specimens, there is a swollen carina along the tabulate shoulder of all the whorls. The strength of the carina varies somewhat from specimen to specimen and is most likely a function of amount of abrasion and degree of preservation.

Clavilithes tabulatus is identical to *Clavilithes* new species Clark and Vokes (1936) from the upper portion ("Domengine Stage") of the Llajas Formation, Simi Valley, California (Clark and Vokes, 1936; Squires, 1984). Givens and Kennedy (1976) also found it in strata of probable "Domengine" age from northern San Diego County, California.

Subfamily Fusininae Swainson, 1840

Genus *Streptochetus* Cossmann, 1889

Type Species. By original designation, *Fusus intortus* Lamarck.

***Streptochetus californiana* new species**

Figures 56, 57

Diagnosis. Generic assignment based on the small, fusiform shell, moderately long anterior canal with siphonal fas-

ciole showing an umbilical slit, and ornament of noded collabral costae crossed by spiral ribs. Specific assignment based on the 12 to 13 collabral costae and numerous primary spiral ribs alternating with secondary ribs.

Streptochetus californiana new species is very similar to *Streptochetus obliquatus* (Deshayes, 1824:542, pl. 74, figs. 13, 14; Cossmann and Pissarro, 1910–1913:pl. 40, fig. 197-7) from lower Eocene strata (Cuisian Substage) of the Paris Basin, France. *Streptochetus californiana* differs from *S. obliquatus* in the following features: 12 to 13 collabral costae rather than seven or eight, primary spiral ribs not as strongly developed on the upper spire, and collabral costae more strongly developed on the spire.

Description. Shell small, elongate-fusiform, with five and one-half whorls. Suture area coincident with one to two prominent spiral ribs that form a band. Protoconch missing. Teleoconch whorls angulate anterior to this sutural band and with 12 to 13 collabral costae that are as strongly developed in this sutural band region as elsewhere. The collabral costae also tend to become obsolete on the body whorl. Costae are noded where crossed by finer primary spiral ribs that number about six on the spire whorls and about ten on the body whorl. The posteriormost two primary spiral ribs on the body whorl occupy the sutural area and form a distinct area in which the collabral costae are not strongly developed. On the anterior portion of the penultimate whorl there can be a secondary spiral rib between the primaries that approaches the primaries in strength. On the posterior of the body whorl, there can be one to three secondary spiral ribs or three tertiary spiral riblets between the primaries. Teleoconch covered by very fine growth lines. Oblique neck area moderately long with about eight primary spiral ribs that can have a secondary rib in the interspaces.

Aperture oval. Outer lip missing. Siphonal fasciole well developed and showing an umbilical slit. Holotype height (nearly complete) 19 mm, width (complete) 8 mm.

Primary Type Material. LACMIP holotype 7480, Juncal Formation, CSUN locality 845.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 360, 845.

Remarks. Three specimens were found and preservation is fair to moderately good. The holotype is slightly crushed in the posterior portion of the outer lip area. The specimen from locality 360 is only 9 mm in height (incomplete).

The geologic range of *Streptochetus* is from early Eocene into the Pliocene (Wenz, 1943; Palmer, 1974; Davies, 1975). The earliest known species is from the Upper Ranikot strata, Pakistan (Davies, 1975). Hasson (1985) has shown these strata to be assignable to the early Eocene. A few species have been found in lower Eocene strata (Cuisian Substage) of the Paris Basin, France, and nine species have been found in middle Eocene strata (Lutetian Stage) there (Chédeville, 1904b; Cossmann and Pissarro, 1910–1913). Only two definite species have been found in middle Eocene strata of Alabama (Palmer and Brann, 1966). *Streptochetus californiana* new species is the first record of this genus on the West Coast.

Etymology. The species is named for the state of California.

Superfamily Volutacea

Family Olividae Latreille, 1825

Genus *Pseudoliva* Swainson, 1840

Type Species. By original designation, *Buccinum plumbea* Chemnitz, 1780? [=*Buccinum crassa* Gmelin, 1788?].

Pseudoliva dilleri Dickerson, 1914

Figure 58

Pseudoliva dilleri Dickerson, 1914c:122–123, pl. 12, figs. 1a–d. Turner, 1938:77–78, pl. 18, figs. 7–8. Weaver, 1943: 458–459, pl. 89, figs. 5–6, 10–12.

Primary Type Material. CAS holotype 248, upper Umpqua Formation, UCMP locality A-667.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak area, southern California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 359.

Remarks. Only a single specimen was found. Typical specimens of this species have numerous fine spiral ribs on the whorls, a biangulated body whorl, and obvious nodes on the penultimate whorl and anteriormost body-whorl angulation. The posteriormost body-whorl angulation is only slightly noded and is a tabulation just anterior to the suture. The Whitaker Peak specimen has all these features, but the nodes on the body whorl are weak. In this particular feature, the specimen more closely resembles Vokes' (1939:pl. 18, fig. 23) illustration of the "Domengine Stage" *Pseudoliva lineata* Gabb from the Avenal Sandstone, central California. Gabb (1864:99, pl. 18, fig. 52), however, did not mention the presence of nodes on *P. lineata*. Squires' (1984:fig. 81) illustration of *P. lineata* from the Llajas Formation, southern California, does not show any nodes. As pointed out by Givens (1986, pers. commun.), it is not clear whether *P. dilleri* and *P. lineata* are separate but closely related taxa (i.e., one with nodes and one without) or if they are the same species and represent only geographic variation within a single polytypic species.

Previously, *P. dilleri* had not been reported south of southwestern Oregon.

Genus *Strepsidura* Swainson, 1840

Type Species. By original designation, *Strepsidura costata* Swainson, 1840 [=*Fusus ficulnea* Lamarck, 1822, =*Murex turgida* Solander, 1766].

Strepsidura ficus (Gabb, 1864)

Figure 59

Whitneya ficus Gabb, 1864:104, pl. 28, fig. 216. Dickerson, 1915:69, pl. 9, figs. 5a–d.

Strepsidura ficus (Gabb). Stewart, 1927:404–405, pl. 29, fig. 11. Kleinpell and Weaver, 1963:193, pl. 27, figs. 1–3. Givens, 1974:87, pl. 10, fig. 10. Deméré, Sundberg, and Schram, 1979:pl. 2, fig. 1. Squires, 1984:33, fig. 8m.

Primary Type Material. ANSP lectotype 4331, designated by Stewart (1927:404), Tejon Formation s.l., Fort Tejon, southern California.

Molluscan Stage Range. "Capay" through "Tejon."

Geographic Distribution. San Diego through Fort Tejon area, Kern County, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 360. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237?

Remarks. Four speeimens were found at locality 360, and only a single specimen was found at locality 237. Preservation is fair. The pyriform specimens show the following features that characterize this species. There is a short spire with fine spiral ribs and collabral costae, the latter obsolete on the inflated body whorl. On the rounded shoulder area of the body whorl, the spiral ribs are also obsolete. There is also a rather thickly calloused inner lip with a fairly prominent fold at the base of the columella. The anterior eanal is twisted.

The presence of specimens of *S. ficus* in the *Turritella uvasana infera* fauna of the Whitaker Peak area extends the molluscan stage range of this species into the "Capay Stage" proper. Previously, the lower range limit had been known to be uppermost "Capay" (Squires, 1984).

Strepsidura ficus? was mentioned by Palmer and Brann (1966) as possibly occurring also in middle Eocene strata (lower Claiborne Group) in Texas.

Subfamily Olivinae Swainson, 1840

Genus *Ancilla* Lamarck, 1799

Type Species. By monotypy, *Ancilla cinnamonea* Lamarck, 1801.

Ancilla gabbi Cossmann, 1899

Figure 60

Ancillaria elongata Gabb, 1864:100, pl. 18, fig. 54. Hanna, 1927:323, pl. 53, figs. 9–13. Stewart, 1927:411.

Not *Ancillaria elongata* Gray, 1847a:357, pl. 1, fig. 5.

Ancilla gabbi Cossmann, 1899:60 [new name for *Ancillaria elongata* Gabb, 1864, preoccupied]. Turner, 1938:72, pl. 18, fig. 6. Weaver, 1943:500, pl. 95, fig. 18.

Ancilla (*Spirancilla*) *gabbi* Cossmann. Vokes, 1936:414; 1939: 131, pl. 18, figs. 6, 10. Squires, 1984:34, fig. 8n.

Primary Type Material. UCMP syntypes 12521 (two specimens) of *Ancillaria elongata* Gabb and *Ancilla gabbi* Cossmann, near San Diego, California.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego, California through northwestern Oregon.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 363. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Single specimens were found at each locality. The specimens show the charaeteristic calloused sutures and the single, broad region of the twisted columella with its closely spaced, oblique five folds.

Vokes (1936, 1939) assigned this species to his subgenus *Spirancilla.* Wenz (1943) regarded *Spirancilla* as a junior synonym of the subgenus *Ancillus* Montfort, 1810. Wagner and Abbott (1978) regarded *Ancillus* as a junior synonym of the genus *Ancilla* Lamarck, 1799, and that is the usage adopted for this present report.

Genus *Olivella* Swainson, 1831

Type Species. By subsequent designation (Dall, 1909), *Olivella purpurata* Swainson, 1831 [=*Oliva dama* Mawe, 1823].

Olivella mathewsonii Gabb, 1864

Figure 61

Olivella mathewsonii Gabb, 1864:100, pl. 18, fig. 53. Anderson and Hanna, 1925:80, pl. 8, fig. 19. Stewart, 1927: 410–411, pl. 29, fig. 13. Weaver, 1943:500–501, pl. 103, fig. 7. Givens, 1974:87. Smith, 1975:469, table 1. Squires, 1977:table 1; 1984:34, fig. 8o.

Primary Type Material. ANSP lectotype 4202, designated by Stewart (1927:411), Tejon Formation s.l., Martinez, California.

Molluscan Stage Range. Lower "Martinez" through "Tejon."

Geographic Distribution. Simi Valley, southern California through northwestern Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 359, 361, 827, 845. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Four specimens were found at locality 361. At the other localities, only one or two specimens were found. Preservation is fair to poor, but the best specimens clearly show near the anterior end the two columellar folds characteristic of this species.

Family Volutomitridae Gray, 1854

Genus *Proximitra* Finlay, 1927

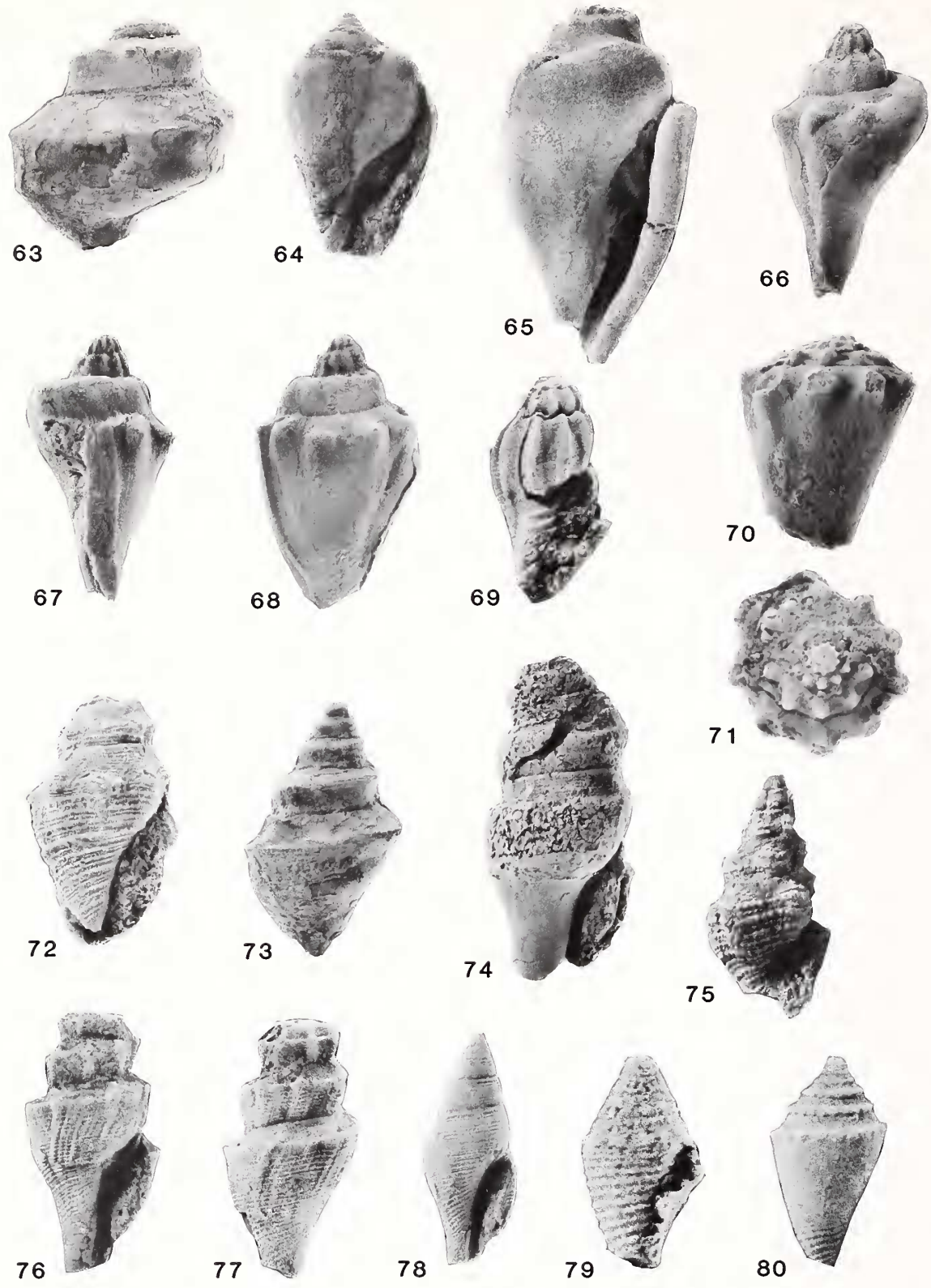
Type Species. By original designation, *Vexillum rutidolomum* Suter, 1917.

Proximitra? *cretacea* Gabb, 1864

Figure 62

Mitra cretacea Gabb, 1864:103, pl. 28, fig. 214. Stewart, 1927:406, pl. 27, figs. 9–10.

Uromitra (?) *cretacea* (Gabb). Vokes, 1939:134–135, pl. 18, fig. 19.



Figures 63–80. Whitaker Peak area Eocene neogastropods. Unless otherwise noted, views are apertural. **63.** *Pseudoperissolax blakei praeblakei* Vokes, 1939, internal mold, abapertural view, ×1.4, height 27 mm, width 25 mm, LACMIP hypotype 7486, CSUN loc. 808. **64.** *Cryptochorda* (*Cryptochorda*) *californica* (Cooper, 1894), ×1.4, height 28.5 mm, width 17 mm, LACMIP hypotype 7487, CSUN loc. 361. **65–68.** *Athleta*

Dentimitra cretacea (Gabb). Cernohorsky, 1970:41; 1976: 280, 510.

Proximitra? cretacea (Gabb). Givens, 1974:87. Squires, 1977: table 1; 1984:34, fig. 8p.

Primary Type Material. ANSP holotype 4302, Tejon Formation s.l., Martinez, California.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley, southern California through central California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Five specimens were found, and they represent a partial growth series, ranging in height from 3 to 10 mm. Preservation of this small species is good.

Givens (1974) considered this species to be more closely related to *Proximitra* than to any other genus because of the presence of the prominent nodose carina on the shoulder of the whorls and the slightly stronger and longer second posterior fold on the columella. After examination of the specimens from locality 237, as well as 46 well-preserved specimens from the Llajas Formation, Simi Valley, California (Squires, 1984:34), Givens' (1974) tentative assignment of this species to *Proximitra*? seems justified. On most specimens from the Whitaker Peak area and the Llajas Formation, the second posterior fold is, indeed, slightly stronger and slightly longer than the first posterior fold. On some specimens from both locality 237 and the Llajas Formation, however, the first and second posterior folds are approximately the same strength although the second fold is the longer of the two.

According to Wenz (1943), the oldest *Proximitra* is Oligocene in age. If the California "Domengine Stage" specimens of *Proximitra? cretacea* do belong to this genus, they would be the oldest forms of *Proximitra*.

Family Tudiclidae Finlay and Marwick, 1937

Genus *Pseudoperissolax* Clark, 1918

Type Species. By original designation, *Busycon? blakei* Conrad, 1855.

Pseudoperissolax blakei praeblakei Vokes, 1939

Figure 63

Not *Busycon? blakei* Conrad, 1855:11; 1857:332, pl. 2, fig. 13.

Perissolax blakei (Conrad). Gabb, 1864:92 (in part), pl. 21, fig. 110.

Pseudoperissolax blakei (Conrad) (subsp.?). Stewart, 1927: 429–430, pl. 28, fig. 1.

Pseudoperissolax blakei praeblakei Vokes, 1939:145–146, pl. 19, figs. 14, 22. Moore, 1968:28, pl. 12b. Givens, 1974: 88, pl. 10, figs. 15–16. Smith, 1975:pl. 2, fig. 16. Squires, 1984:34–35, fig. 9a.

Primary Type Material. UCMP holotype 15799, UCMP paratype 15800, Arroyo Hondo Formation, UCMP locality 1817.

Molluscan Stage Range. Lower "Martinez" through "Domengine."

Geographic Distribution. San Diego, southern California through central California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 808.

Remarks. Only a single specimen was found, and it is mostly an internal mold.

Family Volutidae Rafinesque, 1815

Subfamily Volutinae Rafinesque, 1815

Genus *Cryptochorda* Mörch, 1858

Type Species. By monotypy, *Buccinum stromboides* Herrmannsen.

Subgenus *Cryptochorda* s.s.

Cryptochorda (*Cryptochorda*) *californica* (Cooper, 1894)

Figure 64

Ancilla (*Oliverato*) *californica* Cooper, 1894:43, pl. 1, figs. 6–11. Dickerson, 1913:264; 1914c:115, pl. 12, figs. 4a–b.

Oliverato californica Cooper. Dickerson, 1913:286–287, pl. 13, figs. 4a–b.

Caricella stormsiana Dickerson, 1913:287, pl. 13, figs. 3a–b.

Cryptochorda californica (Cooper). Clark, 1929:pl. 4, figs. 6, 16; pl. 9, figs. 5–6. Clark and Vokes, 1936:874, pl. 1, fig. 5. Turner, 1938:72, pl. 18, figs. 11, 15. Vokes, 1939:139–140. Weaver, 1943:499, pl. 95, figs. 19, 23. Squires, 1984: 35, fig. 9c.

←

roddai new species. All parts CSUN loc. 845. **65.** ×2.2, height 27 mm, width 14 mm, LACMIP holotype 7488. **66.** Side view, ×2, height 23 mm, width 13 mm, LACMIP paratype 7489. **67.** Side view of LACMIP paratype 7489. **68.** Abapertural view of LACMIP paratype 7489. **69.** *Lyria andersoni* Waring, 1917, ×4, height 9.5, width 5 mm, LACMIP hypotype 7490, CSUN loc. 362. **70–71.** *Lyrischapa lajollaensis* (Hanna, 1927). All parts ×1.3, height 27 mm, width 21 mm, LACMIP hypotype 7491, CSUN loc. 827. **70.** Abapertural view. **71.** Apical view. **72.** *Fusiturricula* (*Crenaturricula*) *crenatospira* (Cooper, 1894), ×2.3, height 17.5 mm, height 10 mm, LACMIP hypotype 7492, CSUN loc. 237. **73.** *Surculites mathewsonii* (Gabb, 1864), internal mold, abapertural view, ×1.5, height 28 mm, width 17 mm, LACMIP hypotype 7493, CSUN loc. 358. **74.** *Apiotoma californiana* new species, ×1.5, height 35 mm, width 16 mm, LACMIP holotype 7494, CSUN loc. 360. **75.** *Pleurofusia fresnoensis* (Arnold, 1910), ×2.8, height 14.5 mm, width 7 mm, LACMIP hypotype 7495, CSUN loc. 362. **76–77.** *Eopleurotoma whitakerpeakensis* new species. All parts ×2.5, height 17 mm, width 8 mm, LACMIP holotype 7496, CSUN loc. 827. **77.** Abapertural view. **78.** *Cryptoconus cooperi* (Dickerson, 1916), ×2.1, height 18 mm, width 7 mm, LACMIP hypotype 7497, CSUN loc. 827. **79.** *Conus caleocius* Vokes, 1939, ×7, height 5 mm, width 3 mm, LACMIP hypotype 7498, CSUN loc. 828. **80.** *Conus remondii* Gabb, 1864, abapertural view, ×5, height 7 mm, width 4 mm, LACMIP 7499, CSUN loc. 219.

Primary Type Material. CAS syntypes 8a–d (four specimens), Capay Formation, Sutter Buttes [=Marysville Buttes], Sutter County, northern California.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley, southern California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 360, 361, 850.

Remarks. Two specimens were found at locality 850, and elsewhere only single, poorly preserved specimens were found. The specimens are missing the thickened outer lips. The columellar callus is heavy in the parietal area but thin over the adjacent ventral surface.

Subfamily Athletinae Pilsbry and Olsson, 1954

Genus *Athleta* Conrad, 1853

Type Species. By subsequent designation (Dall, 1890), *Voluta rarispina* Lamarck, 1811.

Athleta roddai new species

Figures 65–68

Diagnosis. Generic assignment based on the strombiform shape (unusual but present in this subfamily), posterior notch, row of nodes along whorl shoulder, thickened columella, and five columellar folds. Specific assignment based on the extensive, thick, parietal callus along body whorl ventral surface, a strongly tabulate shoulder on the penultimate whorl, and small, mostly equal-sized columellar folds.

Athleta roddai new species is most similar to *Athleta tuomeyi* Conrad (1853:449; 1860:298, pl. 47, fig. 35; Cossmann, 1899:pl. 5, fig. 5; Palmer, 1937:373–374, pl. 58, fig. 11; Gardner, 1945:228, pl. 12, figs. 10–12; Fisher, Rodda, and Dietrich, 1964:47–53, pl. 8, figs. 5, 6; Dockery, 1980:115–116, pl. 2, figs. 7a, b) from upper Paleocene through lower Eocene strata, Atlantic and Gulf coastal plains. Maldonado-Koerdell (1950) also tentatively reported *A. tuomeyi* from Eocene strata in Chiapas, Mexico. *Athleta roddai* differs from *A. tuomeyi* in the following features: presence of a strongly tabulate shoulder on the penultimate whorl, no subsutural ridge on spire whorls, nodes on the body whorl shoulder rather than pointed spines, less persistent collabral swellings anterior to nodes on shoulder of body whorl, fewer and less pronounced spiral ribs on base of body whorl, and a more prominent posterior notch. The columellar folds are also closer together, more equal-sized, and smaller than those of *A. tuomeyi.* In addition, the parietal callus is not as extreme and does not spread from the parietal region to cover most of the spire as happens in many specimens of *A. tuomeyi.* It is important to mention, however, the degree of callosity in *A. tuomeyi* is variable (Fisher, Rodda, and Dietrich, 1964).

Description. Shell small, thick, strombiform (but lacking strombid notch), with four angulate whorls. Spire about one-fourth to one-third the height of the shell. Protoconch missing. Spire whorls with ten collabral costae that extend from suture to suture. On penultimate whorl, collabral costae develop nodes on the strongly tabulate whorl shoulder. Sutural ramp on penultimate whorl with five closely spaced spiral riblets, also present on sutural ramp of early portion of body whorl. Sides of penultimate whorl obscured somewhat by parietal callus deposited during formation of the penultimate whorl. Body whorl with five to six nodes on shoulder; earlier whorls concealed by a thick parietal callus that extends to base of body whorl, thinning anteriorly. Collabral swellings associated with the body whorl nodes continue a short distance anteriorly. Neck area with about five spiral riblets, accentuated anteriorly.

Aperture narrow with a posterior notch. Middle portion of columella slightly indented. Immediately anterior to this indentation are four to five, closely spaced small folds. The anteriormost fold is the most prominent. Outer lip thickened. Anterior canal region missing. Holotype height (nearly complete) 27 mm, width (complete) 14 mm.

Primary Type Material. LACMIP holotype 7488, LACMIP paratype 7489, Juncal Formation, CSUN locality 845.

Molluscan Stage Range. "Capay Stage."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 845.

Remarks. Four nearly complete and three fragmental specimens were found. The nearly complete specimens range in height from 19 to 27 mm.

Athleta normally does not have extensive, thick parietal callus deposits. Only certain species do, and Darragh (1971) cited seven examples, ranging in age from early Eocene through early Miocene. Two of the best examples are the late Paleocene through early Eocene *A. tuomeyi,* which *A. roddai* new species most closely resembles, and the early Miocene *A. rarispina* (Lamarck), the type species of *Athleta.*

Athleta is a common genus of the Eocene in the Atlantic and Gulf coastal plains (Fisher, Rodda, and Dietrich, 1964; Rodda and Fisher, 1964), as well as in the anglo-Paris Basin (Cossmann and Pissarro, 1910–1913; British Museum of Natural History, 1975). According to Davies (1975), the genus originated in Pakistan where it has been found in the Upper Ranikot beds, assigned an early Eocene age by Hasson (1985). Fisher, Rodda, and Dietrich (1964), however, reported *Athleta tuomeyi* from the upper Paleocene and lower Eocene Wilcox Group of Louisiana, and Givens (1986, pers. commun.) has collected *A. tuomeyi* from the upper Paleocene (Thanetian) Bells Landing Marl Member of the Tuscahoma Sand, Alabama. Darragh (1971), furthermore, reported the presence of *Athleta* in upper Paleocene strata of Victoria, Australia. Until recently, species have been reported (Fisher, Rodda, and Dietrich, 1964) from strata as young as the Burdigalian (early Miocene) of the Aquitaine Basin, France. Darragh (1971), however, reported the occurrence of a single living species of *Athleta* (*Ternivoluta*) in southeastern Australia.

In addition to *Athleta roddai* new species, there is only one other West Coast species assignable to *Athleta;* namely, *Voluta lawsoni* Dickerson (1913:284, pl. 12, figs. 5a–c) from lower Eocene strata, Sutter Buttes [=Marysville Buttes], northern California. Stewart (1927:408) assigned Dickerson's

speeies to *Volutocorbis* (*Volutospina*). An examination of the holotype of Dickerson's species confirmed Stewart's assignment of this species to *Volutospina* based on the following morphologieal features: presence of a ribbed stage followed by a cancellate stage on the protoconch, tabulate nature of the shoulder, spinose nature of the nodes on the shoulder, and strong collabral costae on the posterior half of the body whorl. Dickerson's species, however, does not have the subsutural spiny ridge that is usually a common characteristic of *Volutospina* according to Fisher, Rodda, and Dietrich (1964). Dickerson's species also does not have the cancellate sculpture that is usually a distinguishing feature of *Volutocorbis*. Darragh (1971), however, reported that there is a gradation in morphology among *Volutocorbis, Volutospina,* and *Athleta*. He considered *Volutocorbis* and *Volutospina* as synonyms of *Athleta*. *Athleta roddai* new species and *A. lawsoni* (Dickerson), therefore, are the only known species of this genus on the West Coast. Anderson (1928) described *Athleta* (*Volutospina*) *caracoli* from Eocene strata of Colombia, South America, but Clark and Durham (1946) assigned the species to *Morum* (*Herculea*).

Etymology. The species is named for Peter U. Rodda in recognition for his research on *Athleta*.

Subfamily Lyriinae Pilsbry and Olsson, 1954

Genus *Lyria* Gray, 1847b

Type Species. By original designation, *Voluta nucleus* Lamarck, 1811.

Lyria andersoni Waring, 1917

Figure 69

Cancellaria irelaniana Cooper. Arnold, 1910:52, pl. 4, fig. 22. [Misidentification.]

Lyria andersoni Waring, 1917:97, pl. 15, fig. 12. Clark, 1929: pl. 9, figs. 7–8. Clark and Vokes, 1936:876, pl. 1, fig. 17. Turner, 1938:73, pl. 18, fig. 5. Vokes, 1939:136, pl. 18, figs. 22, 24. Hanna and Hertlein, 1941:170, fig. 62-21. Squires, 1984:35, pl. 9d.

Primary Type Material. SU holotype 195, SU paratype 196, Llajas Formation, SU locality 2696.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley, southern California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 360, 362, 807?, 814, 827, 845.

Remarks. Less than five specimens were found at each locality, and preservation is fair. Previously, this species had not been reported, with certainty, as ranging into the "Capay Stage." Turner (1938) reported *L. andersoni* from the upper Umpqua Formation (Glide section), which he considered as probably equivalent to the "Capay Stage."

Subfamily Fulgorarinae Pilsbry and Olsson, 1954

Genus *Lyrischapa* Aldrich, 1911

Type Species. By monotypy, *Lyrischapa harrisi* Aldrich, 1911.

Lyrischapa lajollaensis (Hanna, 1927)

Figures 70, 71

Pejonia lajollaensis Hanna, 1927:320, pl. 52, figs. 1–2.

Volutospira (*Pejonia*) *lajollaensis* (Hanna). Clark, 1929, pl. 9, figs. 11–12.

Volutocristata lajollaensis (Hanna). Gardner and Bowles, 1934:246, fig. 13. Hanna and Hertlein, 1941:fig. 62-29. Givens, 1974:88.

Lyrischapa lajollaensis (Hanna). Givens, 1979:124–126, pl. 3, figs. 1–2; pl. 4, figs. 1–3. Givens and Kennedy, 1979: table 1. Squires, 1984:36, fig. 9e.

Primary Type Material. Holotype lost, UCMP neotype 14634 designated by Givens (1979), Ardath Shale, UCMP locality 5062.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. San Diego through Pine Mountain area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 802, 810, 827, 833, 837.

Remarks. At all the localities, except 827, only one or two specimens were found. Preservation is fair. At locality 827 four specimens were found. As noted by Givens (1979), each whorl of the adult part of the shell of this species typically envelops the preceding whorl up to the shoulder so that only the tips of the peripheral spines are exposed. At locality 827, one of the specimens shows some variation in this respect, as the entire peripheral spines are exposed and not just the tips. In general, the tips of the peripheral spines on all the Whitaker Peak specimens are robust.

Previously, this species had not been reported as ranging into the "Capay Stage." Its presence there also extends the age range of the genus into the early Eocene. Previously, the earliest record of the genus was reported as middle Eocene (Givens, 1979).

Superfamily Conacea

Family Turridae Swainson, 1840

Subfamily Turriculinae Powell, 1942

Genus *Fusiturricula* Woodring, 1928

Type Species. By original designation, *Turris* (*Surcula*) *fusinella*.

Subgenus *Crenaturricula* Vokes, 1939

Type Species. By original designation, *Surcula crenatospira* Cooper, 1894.

Fusiturricula (*Crenaturricula*) *crenatospira* (Cooper, 1894)

Figure 72

Surcula crenatospira Cooper, 1894:39, pl. 1, figs. 2–4. Dickerson, 1913:278, pl. 11, fig. 4.
Fusiturricula (*Crenaturricula*) *crenatospira* (Cooper). Vokes, 1939:114–115, pl. 17, figs. 4–5. Powell, 1966:pl. 2, fig. 14. Squires, 1984:36–37, fig. 9h.
Nekewis io (Gabb). Squires, 1977:table 1. [Misidentification.]

Primary Type Material. CAS syntypes 9a, b (two specimens), Capay Formation, UCMP locality 1853.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley, southern California through Sutter Buttes [=Marysville Buttes], northern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 359. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Two specimens were found at locality 359, and only one specimen was found at locality 237. The latter specimen was originally identified by Squires (1977) as *Nekewis io*.

Fusiturricula (*Crenaturricula*) *crenatospira* is characterized by the presence of collabral costae anterior to the nodes on the spire and the body whorl.

Genus *Surculites* Conrad, 1865

Type Species. By monotypy, *Surcula* (*Surculites*) *annosus* Conrad, 1865.

Surculites mathewsonii (Gabb, 1864)

Figure 73

Fusus mathewsonii Gabb, 1864:83, pl. 18, fig. 33. Dickerson, 1914d:pl. 16, fig. 2.
Bela clathra Gabb, 1869:152, pl. 26, fig. 31.
?*Pleurotoma decipiens* Cooper, 1894:40, pl. 2, fig. 32.
Potamides? *davisiana* Cooper, 1894:44, pl. 1, fig. 13.
Surcula davisiana (Cooper). Dickerson, 1913:279, pl. 12, figs. 6a–b.
Surcula(?) sp. Waring, 1917:pl. 15, fig. 16.
Surcula decipiens (Cooper). Hanna, 1927:324, pl. 54, figs. 6, 8.
Surculites mathewsonii (Gabb). Stewart, 1927:420–421, pl. 26, figs. 12–14. Clark, 1929:pl. 9, figs. 3–4. Turner, 1938: 69–70, pl. 17, figs. 6, 10. Vokes, 1939:123, pl. 17, figs. 8, 19. Weaver, 1943:526, pl. 97, figs. 24, 29; pl. 98, figs. 1, 5; 1953:29. Givens, 1974:90, pl. 11, figs. 5, 7. Zinsmeister, 1974:164, pl. 17, fig. 6; 1983a:table 1. Squires, 1977:table 1; 1984:37, fig. 9j. Givens and Kennedy, 1979:87, tables 1, 3.
"*Surculites*" *mathewsonii* (Gabb). Smith, 1975:pl. 2, fig. 15.

Primary Type Material. ANSP lectotype 4180, designated by Stewart (1927:420), Tejon Formation s.l., near Martinez, California.

Molluscan Stage Range. Lower "Martinez" through "Transition."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 358. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 219.

Remarks. Single specimens were found at each locality, and they are internal molds.

Genus *Apiotoma* Cossmann, 1889

Type Species. By original designation, *Pleurotoma pirulata* Deshayes, 1834.

***Apiotoma californiana* new species**

Figure 74

Diagnosis. Genus assignment based on medium, elongate-fusiform shell with a tall spire, whorls angulate above middle portion, ramp area sunken, and weak spiral sculpture. Specific assignment based on whorls strongly angulate, anterior half of whorls nearly straight-sided, whorls covered with spiral threads (strongest in area between suture and shoulder).

Apiotoma californiana new species is similar to *Apiotoma pirulata* (Deshayes, 1834:449, pl. 66, figs. 1–3; Cossmann and Pissarro, 1910–1913:pl. 51, fig. 223 *bis* 19; Wenz, 1943: fig. 3914; Powell, 1966:36, pl. 3, fig. 23), the type species, from lower and middle Eocene strata (Cuisian Substage and Lutetian Stage) of the Paris Basin, France. *Apiotoma californiana* differs from examined specimens of *A. pirulata* in the following features: larger, more angulate whorls, spiral sculpture much less prominent (especially anterior to the shoulder), shoulder slope more sunken, absence of any tendency for weak collabral sculpture, and absence of weak cancellate sculpture.

Apiotoma californiana new species differs from *A. andersoni* (Dickerson, 1914d:149, pl. 16, fig. 11; Zinsmeister, 1974: 164–165, pl. 17, figs. 1–4) from upper Paleocene strata in California and the only other species of this genus on the West Coast in the following features: lack of nodes on the angulation and no spiral ribbing that alternates in size on the body whorl.

Description. Shell medium, elongate-fusiform, with three and one-half whorls. Uppermost spire whorls missing. Teleoconch whorls strongly angulate just posterior to middle portion. Thickened spiral cord along suture. Ramp area sunken and covered with about five weak spiral ribs that can have secondary ribs in between anteriorly. Ramp area also with broadly arcuate growth lines. Angulate shoulder with weak spiral ribs. Anterior half of whorls nearly straight-sided and covered with numerous and closely spaced, very weak spiral ribs. Ribbing tends to become somewhat obsolete along base of body whorl.

Aperture narrow. Inner lip smooth. Outer lip broken and posterior notch area not preserved although the broadly arcuate growth lines clearly show the posterior notch shape. Anterior end of body whorl broken. Holotype height (incomplete) 35 mm, width (complete) 16 mm.

Primary Type Material. LACMIP holotype 7494, Juncal Formation, CSUN locality 360.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 360.

Remarks. Only a single specimen was found, and preservation is fair.

Apiotoma ranges from late Paleocene through Recent (Cossmann and Pissarro, 1909; Dickerson, 1914d; Powell, 1966; Davies, 1975; Zinsmeister, 1974, 1983a). One late Paleocene species, *A. andersoni* (Dickerson), has been found in California. This species is the earliest reported species of this genus in the Western Hemisphere. It is present in the "Martinez Stage" Santa Susana Formation, Simi Hills, southern California (Zinsmeister, 1974, 1983a) and in "Martinez"-age strata in the San Francisco region (Dickerson, 1914d). *Apiotoma californiana* new species is the first reported Eocene species of this genus in the Western Hemisphere. Two earliest Eocene species have been found in Pakistan (Davies, 1975; Hasson, 1985), one early and middle Eocene species (the type species) has been found in the Paris Basin, several Oligocene and Miocene species have been found in southeastern Australia, several Miocene species have been found in Java, and one Recent species has been found in the Philippines (Powell, 1966).

Powell (1966) stated that the whorls are only weakly angulate in *Apiotoma,* but in the figures given by Cossmann and Pissarro (1910–1913) for the type species, the whorls are rather strongly angulate.

Etymology. The species is named for the state of California.

Genus *Pleurofusia* Gregorio, 1890

Type Species. By original designation, *Pleurotoma* (*Pleurofusia*) *longirostropis* Gregorio, 1890.

Pleurofusia fresnoensis (Arnold, 1910)

Figure 75

Pleurotoma fresnoensis Arnold, 1910:53, pl. 4, fig. 23.
Surcula clarki Dickerson, 1913:278, pl. 11, fig. 3.
Surcula lindavistaensis Hanna, 1927:325–326, pl. 56, figs. 3, 7–8.
Pleurofusia fresnoensis (Arnold). Vokes, 1939:117–118, pl. 17, figs. 15–16. Givens, 1974:90, pl. 11, fig. 9. Givens and Kennedy, 1979:95, tables 1, 3. Squires, 1984:36, fig. 9g.

Primary Type Material. USNM holotype 165631, Domengine Formation, USGS locality 4619.

Molluscan Stage Range. "Capay" through "Transition."

Geographic Distribution. San Diego through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 362. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Only a single specimen was found at locality 362, and two specimens were found at locality 237. Preservation is fair, but the anterior canal is missing in all the specimens. The specimens show the characteristic ornamentation of this species; namely, sharply angulated whorls with swollen nodes crossed by two strong spiral ribs.

Keen and Bentson (1944) assigned *Surcula lindavistaensis* to *Pleurofusia lindavistaensis.* Givens and Kennedy (1979) regarded *Pleurofusia fresnoensis* to be synonymous with *Surcula lindavistaensis.*

Subfamily Turrinae Powell, 1942

Genus *Eopleurotoma* Cossmann, 1889

Type Species. By original designation, *Pleurotoma multicostata* Deshayes, 1834.

Eopleurotoma whitakerpeakensis new species

Figures 76, 77

Diagnosis. Generic assignment based on fusiform shape, straight columella, U-shaped growth lines on ramp area, and collabral costae noded posteriorly. Specific assignment based on the seven collabral costae and numerous spiral ribs anterior to the strongly angulate shoulder.

Eopleurotoma whitakerpeakensis new species is similar to *Pleurotoma* (*Eopleurotoma?*) *amphibola* Cossmann and Pissarro (1909:14, pl. 1, figs. 33–35; Powell, 1969:303, pl. 236, figs. 2, 3) from the Upper Ranikot strata, Pakistan. According to Hasson (1985), these strata are assignable to an early Eocene age. *Eopleurotoma whitakerpeakensis* differs from *P.* (*E.?*) *amphibola* in the following features: more angulate whorls, collabral costae less swollen, absence of a suprasutural fold (preservation may be responsible for this), and absence of spiral ribs on ramp between suture and shoulder.

Eopleurotoma? traski Vokes (1939:116–117, pl. 17, fig. 9) is the only other reported species of *Eopleurotoma* (albeit a questionable assignment) from the West Coast Tertiary, and it is from middle Eocene strata near Coalinga, central California. *Eopleurotoma whitakerpeakensis* new species differs from *E.? traski* in the following features: shoulder nearer the suture and more strongly angulated, much less sloping ramp area, absence of spiral ribs on ramp, seven rather than nine collabral costae on the whorls, much stronger nodes on the body whorl, and more uniform strength spiral ribbing on the whorls. The presence of a well-developed siphonal fasciole on *E.? traski* indicates assignment to another genus because according to Davies (1975) *Eopleurotoma* has no siphonal fasciole.

Description. Shell small, fusiform. Upper spire missing. Three and one-half strongly angulate whorls. Slightly concave ramp area between suture and shoulder essentially smooth except for U-shaped growth lines and very faint spiral threads. Angulate shoulder with seven noded, swollen collabral costae that extend anteriorly to next suture. Nodes and collabral costae tend to become obsolete on body whorl. Numerous spiral ribs anterior to the shoulder on all whorls and on neck area. These spiral ribs are slightly finer and more closely spaced along the noded area of the shoulder.

Aperture narrow. Inner lip smooth. Outer lip broken and

posterior notch area not preserved although the U-shaped growth lines clearly show the posterior notch shape. Holotype height (incomplete) 17 mm, width (complete) 8 mm.

Primary Type Material. LACMIP holotype 7496, Juncal Formation, CSUN locality 827.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 827.

Remarks. Only two specimens were found and both are incomplete. Preservation is good.

The earliest known species of *Eopleurotoma* is from the Upper Ranikot strata, Pakistan (Davies, 1975). According to Hasson (1985), these strata are assignable to an early Eocene age. The geologic range of *Eopleurotoma* is from early Eocene into the Oligocene (Wenz, 1943; Powell, 1966; Davies, 1975). It is common in the Paris Basin, France, Eocene and is fairly common in the southeastern United States Eocene. Two species, which are much less angulate than *E. whitakerpeakensis,* have been reported from the upper Eocene Talara Formation of northern Peru (Olsson, 1930:29–30; Powell, 1966: 45). *Eopleurotoma whitakerpeakensis* is the only species in the West Coast Tertiary that seems to actually belong to this genus. The morphologic variation within *Eopleurotoma* is considerable. Strongly angulate species are the exception rather than the norm, and it is certainly possible that with future taxonomic work, *E. whitakerpeakensis* may be transferred to another turrid genus. According to Davies (1975), there should be a row of crenulations on a posterior sutural thread in *Eopleurotoma.* This feature is apparently absent on *E. whitakerpeakensis.* More taxonomic work is needed to establish if this sutural thread is a constant generic characteristic.

Etymology. The species is named for Whitaker Peak in the study area.

Subfamily Cryptoconinae Wenz, 1943

Genus *Cryptoconus* Koenen, 1867

Type Species. By subsequent designation (Cossmann, 1889), *Pleurotoma filosa* Lamarck.

Cryptoconus cooperi (Dickerson, 1916)

Figure 78

Drillia cooperi Dickerson, 1916:491, pl. 40, figs. 6a–b.
Cryptoconus injucundus Hanna, 1924:164.
Turricula? cooperi (Dickerson). Clark and Woodford, 1927: 109, figs. 8–10.
Cryptoconus cooperi (Dickerson). Clark, 1929:pl. 5, fig. 3. Clark and Vokes, 1936:875, pl. 1, fig. 13. Turner, 1938: table 8. Vokes, 1939:124, pl. 17, fig. 17.

Primary Type Material. UCMP holotype 11824, UCMP paratype 11825, lower Eocene strata, UCMP locality 1853.

Molluscan Stage Range. "Meganos" through "Domengine."

Geographic Distribution. Whitaker Peak area, southern California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 802?, 827, 845.

Remarks. Eight adult specimens were found at locality 827. Preservation is fair to good. The upper spire regions are poorly preserved, however. Only one or two poorly preserved specimens were found at the other localities.

This small species is characterized by a slender fusiform shell with a moderately long anterior canal, a smooth columella, and a posterior notch that produces an anal band posteriorly on the rounded whorls. In well-preserved specimens, the shell surface is completely covered with fine to coarse spiral ribs. Some of the poorly preserved specimens at locality 827 have only three or so spiral ribs just anterior to the posterior anal band on the otherwise smooth spire whorls, as do some of the hypotypes illustrated by other workers; namely, UCMP hypotypes 31264 and 31265 (Clark and Woodford, 1927:pl. 19, figs. 8, 9, respectively) and UCMP hypotype 15780 (Clark and Vokes, 1936:pl. 1, fig. 13). UCMP hypotype 31273 (Clark and Woodford, 1927:pl. 19, fig. 10) and the holotype of *C. cooperi* have spiral ribbing over the entire shell surface.

Hanna (1924) renamed *Drillia cooperi* Dickerson because he believed that the name was preoccupied by Arnold's (1903: 203, pl. 7, fig. 3) *Pleurotoma (Dolichotoma) cooperi.* Vokes (1939) assigned Arnold's species to genus *Megasurcula,* thereby avoiding the need to rename Dickerson's species. Hanna's (1924) use of *Cryptoconus,* however, was retained by later workers. Clark and Woodford (1927) questionably referred the species to *Turricula,* but such an assignment is not suitable as the whorls of a typical *Turricula* are angulated.

Cossmann and Pissarro (1910–1913:pl. 49) illustrated 20 species of *Cryptoconus* from Paris Basin, France, Eocene strata. Many of these species are closely allied to *C. cooperi,* but *C. priscus* (Cossmann and Pissarro, 1910–1913:pl. 49, fig. 216b) from middle and upper Eocene strata (Lutetian and Bartonian stages) of the Paris Basin seems to be most closely allied, especially in terms of the anal band and the presence of ribbing over the entire shell surface. Clark and Vokes (1936:pl. 1, figs. 13, 14) also recognized this close similarity, and according to them, *C. cooperi* differs from *C. priscus* in that the whorls of the California species are somewhat more inflated and the anterior canal is slightly more sharply delineated from the rest of the shell.

Family Conidae Rafinesque, 1815

Genus *Conus* Linné, 1758

Type Species. By subsequent designation (Children, 1823), *Conus marmoreus* Linné, 1758.

Conus caleocius Vokes, 1939

Figure 79

Conus caleocius Vokes, 1939:127–129, pl. 18, figs, 1, 7. Squires, 1984:39, fig. 9m.

Primary Type Material. UCMP holotype 15785, Llajas Formation, UCMP locality 3310.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley, southern California through central California.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828.

Remarks. Only a single specimen was found. Preservation is good. This species is characterized by the presence of strong spiral ribs over the entire body whorl, 13 to 14 nodes on the shoulder of the body whorl, and a row of small nodes immediately anterior to the suture.

Conus remondii Gabb, 1864

Figure 80

Conus remondii Gabb, 1864:122, pl. 20, fig. 79. Waring, 1917:pl. 15, fig. 4. Hanna, 1927:328, pl. 56, figs. 4–5, 15–16. Stewart, 1927:414–415, pl. 29, fig. 15. Clark, 1929:pl. 10, fig. 16; pl. 13, fig. 13. Squires, 1977:table 1.

?*Conus remondii* Gabb. Anderson and Hanna, 1925:100–101, pl. 8, fig. 7.

Primary Type Material. ANSP lectotype 4237, designated by Stewart (1927:414), Tejon Formation s.l., Grapevine Canyon, Kern County, California.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. San Diego through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN localities 363, 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 231.

Remarks. At most of the localities five specimens were found, except at localities 358, 359, and 231, where single specimens were found. Preservation is fair to good. This species is characterized by the presence of about 22 nodes on the shoulder of the body whorl and strong spiral ribs on the anterior portion of the body whorl. Previously, this species had not been reported as ranging into the "Capay Stage."

Conus hornii piruensis new subspecies

Figures 81, 82

Diagnosis. Generic assignment based on inverted conical shape and high aperture with parallel sides. Specific assignment based on moderately high spire, angulate body whorl, and spire whorls concave with a few spiral ribs. Subspecific assignment based on numerous spiral ribs in concave portion of body whorl posterior to unnoded angulate shoulder.

Conus hornii piruensis new subspecies is most similar to *Conus hornii umpquaensis* Turner (1938:69, pl. 15, figs. 1, 2; Vokes, 1939:127, pl. 18, fig. 2; Weaver, 1943:510–511, pl. 96, fig. 18; Stewart, 1946:pl. 11, fig. 6; Givens and Kennedy, 1979:87, tables 1, 3; Squires, 1984:39, fig. 9n) from middle Eocene strata ("Domengine" through "Transition" "Stages"), San Diego, California through southwestern Oregon. *Conus hornii piruensis* differs from *C. hornii umpquaensis* in having spiral ribs over the entire shell surface rather than only on the anterior portion of the body whorl.

Conus hornii piruensis new subspecies is similar to *Conus submonilifer* Anderson and Hanna (1925:99–100, pl. 8, fig. 6) from upper Eocene ("Tejon Stage") strata, Kern County, southern California. *Conus hornii piruensis* differs from *C. submonilifer* in the following features: spiral ribs over the entire shell surface rather than only on the body whorl, concave-sided spire whorls rather than almost straight-sided, and no traces of nodes on the shoulder of the whorls.

Conus hornii piruensis new subspecies is somewhat similar to *Conus hornii* Gabb (1864:122, pl. 29, fig. 226; Dickerson, 1915:pl. 11, figs. 9a–c; Anderson and Hanna, 1925:99; Stewart, 1927:415, pl. 29, fig. 16; Givens, 1974:92, pl. 10, fig. 12) from upper Eocene ("Tejon Stage") strata, central Transverse Ranges, southern California. *Conus hornii piruensis* differs from *C. hornii* in the following features: slightly higher spire (one-third rather than one-fifth of shell height), spiral ribs over entire shell surface, numerous spiral ribs rather than only a few in concave portion of body whorl posterior to shoulder, and absence of fine groove just posterior to the body whorl shoulder.

Conus hornii piruensis new subspecies superficially resembles *Conus weaveri* Dickerson (1915:74–75, pl. 11, fig. 10; Anderson and Hanna, 1925:101–102; Weaver, 1943:512, pl. 96, fig. 26) from the upper Eocene Cowlitz Formation, southwestern Washington. *Conus hornii piruensis* differs from *C. weaveri* in the following features: narrower shell, higher spire, seven rather than three or four fine spiral ribs posterior to penultimate whorl shoulder, nine rather than five fine spiral ribs posterior to body whorl shoulder, less concave in area between suture and whorl shoulder, absence of nodes on spire whorls or on adapical half of body whorl shoulder, and stronger spiral ribs on middle portion of body whorl. Contrary to Dickerson's (1915) description, the holotype of *C. weaveri* is noded, with nodes on the shoulder (i.e., small nodes starting on the adapical half of body whorl shoulder and increasing in size toward the spire apex).

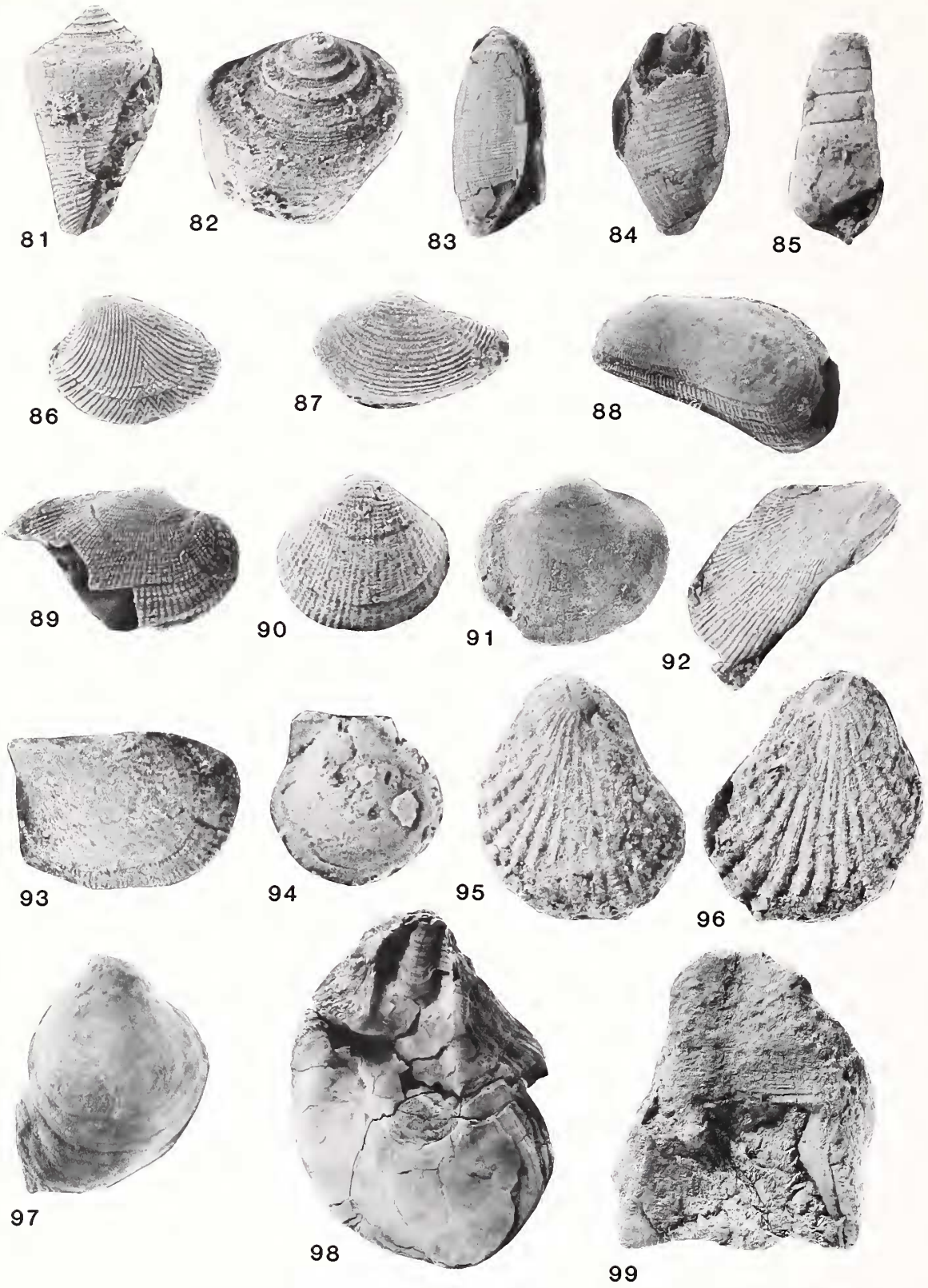
Description. Shell small, biconical, seven to eight whorls, impressed sutures, moderately high spire, approximately one-third of shell height. Protoconch missing. Spire whorls concave, lowermost portion of whorls angulate and slightly beaded in upper spire whorls. Upper spire whorls with about three fine spiral ribs, penultimate whorl with four fine spiral ribs on posterior half and three very fine spiral lirae on anterior half. Body whorl concave posterior to angulate shoulder, with five fine spiral ribs on posterior half of concavity and four very fine spiral threads on anterior half. Body whorl flat-sided anterior to shoulder and covered by numerous well-incised spiral ribs that become stronger and more closely spaced anteriorly.

Aperture long and narrow. Inner lip obscured by matrix. Holotype height (complete) 14 mm, width (complete) 8 mm.

Primary Type Material. LACMIP holotype 7500, Matilija Sandstone?, CSUN locality 237.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Whitaker Peak area, southern California.



Figures 81–99. Whitaker Peak area Eocene neogastropods, cephalaspids, and bivalves. **Figs. 81–82.** Neogastropods. **81–82.** *Conus hornii piruensis* new subspecies. All parts LACMIP holotype 7500, CSUN loc. 237. **81.** Apertural view, ×2.5, height 14 mm, width 8 mm. **82.** Apex tilted to show spire ornamentation, ×4.5, width 8 mm. **Figs. 83–85.** Cephalaspids. **83.** *Cylichnina tantilla* (Anderson and Hanna, 1925),

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Twelve specimens were found, ranging in height from 7 to 22.5 mm. Preservation is good, but all specimens have been affected by weathering. In some of the more weathered specimens, the very fine spiral lirae have been obliterated.

Etymology. The species is named for Piru Creek, southern California.

Subclass Euthyneura

Order Cephalaspidea

Superfamily Cylichnacea

Family Cylichnidae A. Adams, 1850

Genus *Cylichnina* Monterosato, 1884

Type Species. By original designation, *Bulla umbilicata* Montagu, 1803.

Cylichnina tantilla (Anderson and Hanna, 1925)

Figure 83

Cylichnella tantilla Anderson and Hanna, 1925:140, pl. 7, figs. 4, 8–9.

Cylichnina tantilla (Anderson and Hanna). Stewart, 1927: 439–441, pl. 27, figs. 2–4; 1946:pl. 11, fig. 11. Turner, 1938:67–68, pl. 20, figs. 9–10. Vokes, 1939:110, pl. 16, figs. 28, 33, 39. Weaver, 1943:548–549, pl. 100, figs. 10–12, 14–15. Givens, 1974:93. Squires, 1977:table 1; 1983b, fig. 9a; 1984:40, fig. 9p.

Primary Type Material. CAS holotype 958, CAS paratypes 959 and 960, Tejon Formation, CAS locality 711.

Molluscan Stage Range. "Capay" through "Tejon."

Geographic Distribution. Simi Valley, southern California through western Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 360, 361, 364, 802, 805, 807, 827, 830, 831, 832, 835, 841, 845, 846. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN localities 363, 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 231, 232?, 237.

Remarks. At most localities less than three specimens were found. At locality 802 in the *Turritella uvasana infera* fauna and localities 219, 237, and 363 in the *Turritella uvasana applinae* fauna, about 16 specimens were found, and they constitute growth series. Preservation is fair at all localities, but the spiral ribbing in about half of the specimens is not well preserved.

Although it was reported that this species is confined to the "Domengine Stage" (Squires, 1984), it also occurs in the "Capay Stage" (Givens, 1974) as further indicated by its presence in the *Turritella uvasana infera* fauna in the Whitaker Peak area.

Genus *Scaphander* Montfort, 1810

Type Species. By original designation, *Bulla lignaria* Linné, 1767.

Subgenus *Mirascapha* Stewart, 1927

Type Species. By original designation, *Cylichna costata* Gabb, 1864.

Scaphander (*Mirascapha*) *costatus* (Gabb, 1864)

Figure 84

Cylichna costata Gabb, 1864:143–144, pl. 21, fig. 107. Arnold, 1907:pl. 39, fig. 10. Zinsmeister, 1974:170–171, pl. 12, figs. 20–22.

Scaphander costata (Gabb). Hanna, 1927:329, pl. 57, figs. 2–3, 5.

Scaphander (*Mirascapha*) *costatus* (Gabb). Stewart, 1927: 437–438, pl. 27, fig. 5. Turner, 1938:67, pl. 17, fig. 16. Vokes, 1939:109, pl. 16, figs. 29, 35. Moore, 1968:28, pl. 12c. Givens, 1974:93–94. Squires, 1984:40, fig. 9q.

Scaphander costatus (Gabb). Weaver, 1943:545, pl. 100, fig. 2, pl. 103, fig. 21; 1953:29. Givens and Kennedy, 1979: 88, table 3.

←

apertural view, ×3.2, height 11 mm, width 4.5 mm, LACMIP hypotype 7501, CSUN loc. 219. **84.** *Scaphander* (*Mirascapha*) *costatus* (Gabb, 1864), abapertural view, ×2.5, height 14 mm, width 8 mm, LACMIP hypotype 7502, CSUN loc. 291. **85.** ?*Pyramidella preblei* Hanna, 1927, apertural view, ×4, height 9 mm, width 4 mm, LACMIP hypotype 7503, CSUN loc. 237. **Figs. 86–99.** Bivalves. **86.** *Acila* (*Truncacila*) *decisa* (Conrad, 1855), right valve, ×3.1, length 9 mm, height 7 mm, LACMIP hypotype 7504, CSUN loc. 237. **87.** *Hilgardia*? *parkei* (Anderson and Hanna, 1925), left valve, ×3.8, length 8.5 mm, height 5 mm, LACMIP hypotype 7505, CSUN loc. 237. **88.** *Barbatia* (*Barbatia*) cf. *B.* (*B.*) *morsei* Gabb, 1864, left valve, ×1.5, length 27 mm, height 17 mm, LACMIP hypotype 7506, CSUN loc. 358. **89.** *Barbatia* (*Cucullaearca*) *cliffensis* Hanna, 1927, partial right valve, ×3, length 13 mm, height 8 mm, LACMIP hypotype 7507, CSUN loc. 828. **90.** *Glycymeris* (*Glycymeris*) *rosecanyonensis* Hanna, 1927, right? valve, ×3.6, length 8 mm, height 7 mm, LACMIP hypotype 7508, CSUN loc. 237. **91.** *Glycymeris* (*Glycmerita*) *sagittata* (Gabb, 1864), right? valve, ×1.7, length 18 mm, height 17, LACMIP hypotype 7509, CSUN loc. 807. **92.** *Brachidontes* (*Brachidontes*) *cowlitzensis* (Weaver and Palmer, 1922), right valve, ×2, length 10 mm, height 20 mm, LACMIP hypotype 7510, CSUN loc. 237. **93.** *Septifer* (*Septifer*) cf. *S.* (*S.*) *elegans* Waring, 1917, internal mold of left valve, ×2.3, length 11 mm, height 17 mm, LACMIP hypotype 7511, CSUN loc. 364. **94.** Propeamussiid, internal mold of right? valve, ×5.8, length 5 mm, height 5 mm, LACMIP hypotype 7512, CSUN loc. 362. **95–96.** *Plicatula juncalensis* new species. All parts ×2.2, length 15 mm, height 18.5 mm, LACMIP holotype 7513, CSUN loc. 362. **95.** Left valve. **96.** Right valve. **97.** *Ostrea haleyi* Hertlein, 1933, left valve, ×1.6, length 20 mm, height 23 mm, LACMIP hypotype 7514, CSUN loc. 827. **98.** *Ostrea stewarti* Hanna, 1927, interior of right valve, ×0.4, length 97 mm, height 145 mm, LACMIP hypotype 7515, CSUN loc. 216. **99.** *Ostrea* cf. *O. stewarti* Hanna, 1927, interior of left valve, ×0.6, length 75 mm, height 85 mm, LACMIP hypotype 7516, CSUN loc. 364.

Scaphander cf. *S.* (*Mirascapha*) *costatus* (Gabb). Squires, 1977: table 1.

Primary Type Material. ANSP lectotype 4338, designated by Stewart (1927:437), Tejon Formation s.l., near Martinez, California.

Molluscan Stage Range. "Martinez" through "Transition."

Geographic Distribution. San Diego, California through western Washington.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 231, 232, 237, 808.

Remarks. Only single specimens were found at each locality. Preservation is poor. This species is characterized by the very wide aperture and fairly prominent spiral ribbing on the shell exterior.

Superfamily Pyramidellacea

Family Pyramidellidae Gray, 1840

Genus *Pyramidella* Lamarck, 1799

Type Species. By original designation, *Trochus dolabrata* Linné, 1758.

?*Pyramidella preblei* Hanna, 1927

Figure 85

Pyramidella preblei Hanna, 1927:303, pl. 46, figs. 19–21.

Primary Type Material. UCMP holotype 31056, UCMP paratypes 31057 and 31058, Ardath Shale, UCMP locality 3986.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego through Whitaker Peak area?, southern California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Three specimens were found, and they range in height from 1.5 to 8 mm. Because the apertural area is obscured by matrix and the anterior end is missing in each specimen, positive generic and specific identifications cannot be made. No indications of an open umbilicus were observed; therefore, the specimens resemble *P. preblei* more closely than they do *P. etheringtoni* Hanna (1927:302, pl. 46, figs. 14, 18, 22), also from the Ardath Shale, San Diego area.

Class Bivalvia

Subclass Palaeotaxodonta

Order Nuculoida

Superfamily Nuculacea

Family Nuculidae Gray, 1824

Genus *Acila* H. and A. Adams, 1858

Type Species. By subsequent designation (Stoliczka, 1871), *Nucula divaricata* Hinds, 1843.

Subgenus *Truncacila* Schenck *in* Grant and Gale, 1931

Type Species. By original designation *Nucula castrensis* Hinds, 1843.

Acila (*Truncacila*) *decisa* (Conrad, 1855)

Figure 86

Nucula decisa Conrad, 1855:11–12; 1857:pl. 3, fig. 19.

Acila gabbiana Dickerson, 1916:481, pl. 36, fig. 1. Anderson and Hanna, 1925:176, pl. 9, fig. 12.

Nucula (*Acila*) *stillwaterensis* Weaver and Palmer, 1922:6, pl. 8, fig. 8.

Acila lajollaensis Hanna, 1927:270, pl. 25, figs. 1, 3, 5, 7–8, 12, 15.

Acila (*Truncacila*) *decisa* (Conrad). Schenck, 1936:53–56, pl. 3, figs. 1–9, 11–15; pl. 4, figs. 1–2; text fig. 7 (22, 23, 25). Turner, 1938:41–42, pl. 5, figs. 2–3. Vokes, 1939:41, pl. 1, figs. 7–8. Weaver, 1943:22–23, pl. 6, figs. 1, 4, 8; pl. 7, figs. 8–9. Moore, 1968:30, pl. 13a; 1983:10, pl. 1, fig. 14. Givens, 1974:38, pl. 1, fig. 1. Zinsmeister, 1974:67–68, pl. 6, fig. 3; 1983a:table 1. Squires, 1977:table 1; 1984:41, fig. 10a.

Primary Type Material. UCMP neotype 31132, designated by Schenck (1936:55), Ardath Shale, UCMP locality 5062.

Molluscan Stage Range. "Martinez" through upper Eocene (*Turritella schencki delaguerrae* Zone of Kleinpell and Weaver, 1963).

Geographic Distribution. San Diego, California through Kamchatka, U.S.S.R.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Twenty-six disarticulated specimens were found at locality 237. Preservation is excellent. There are about equal numbers of right and left valves, and there is a partial growth series with specimens ranging in height from 5 to 11 mm.

Superfamily Nuculanacea

Family Nuculanidae H. and A. Adams, 1858

Genus *Hilgardia* Harris and Palmer, 1946

Type Species. By original designation, *Leda multilineata* Conrad, 1855.

Hilgardia? *parkei* (Anderson and Hanna, 1925)

Figure 87

Leda parkei Anderson and Hanna, 1925:179–180, pl. 2, figs. 10–11.

Nuculana (*Saccella*) *parkei* (Anderson and Hanna). Givens, 1974:39.

Hilgardia? *parkei* (Anderson and Hanna). Moore, 1983:22–23, pl. 3, figs. 6–7.

Primary Type Material. CAS holotype 782, Tejon Formation, CAS locality 244.

Molluscan Stage Range. "Capay" through "Tejon."

Geographic Distribution. San Diego through Coalinga area, California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Five specimens were found and three are right valves. This taxodont bivalve is charaeterized by its commarginal ribbing and the presence of three umbonal ridges in the posterior area. The commarginal ribbing in the Whitaker Peak specimens is somewhat more even than is usual for *H.? parkei.*

Hilgardia is confined to North America. *Hilgardia? parkei* is the earliest known species in North America and is the only one on the West Coast (Palmer and Brann, 1965; Moore, 1983).

Subclass Pteriomorpha

Order Arcoida

Superfamily Arcacea

Family Arcidae Lamarck, 1809

Subfamily Arcinae Lamarck, 1809

Genus *Barbatia* Gray, 1842

Type Species. By subsequent designation (Gray, 1857), *Arca barbata* Linné, 1758.

Subgenus *Barbatia* s.s.

Barbatia (*Barbatia*) cf. *B.* (*B.*) *morsei* Gabb, 1864

Figure 88

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 358.

Remarks. Only a single specimen was found, and it was collected by Shepard (1960) at UCLA locality 7210 = CSUN locality 358. The specimen is a nearly complete left valve that has the same outline and posterior umbonal ridge with a shallow depression in front of it that *B.* (*B.*) *morsei* possesses. Most of the surface of the specimen, however, is obscured or possibly worn away and no sculpture pattern can be detected. Remnants of the sculpture can be seen along the edges of the specimen. Cancellate ornamentation is present there and resembles that on *B.* (*B.*) *morsei.*

This species has been reported from possible "Capay Stage" strata (Dickerson, 1916) in northern California and from "Domengine Stage" strata (Arnold, 1910; Dickerson, 1916; Hanna, 1927; Clark, 1929; Stewart, 1930; Vokes, 1939; Reinhart, 1943; Givens, 1974; Moore, 1983) in southern through central California. If the specimen from CSUN locality 358 is *B.* (*B.*) *morsei,* then it would be the first occurrence in "Capay"-age strata in southern California.

Subgenus *Cucullaearca* Gray, 1857

Type Species. By subsequent designation (Stoliczka, 1871), *Byssoarca lima* Conrad, 1847.

Barbatia (*Cucullaearca*) *cliffensis* Hanna, 1927

Figure 89

Barbatia cliffensis Hanna, 1927:272, pl. 26, figs. 1–6.

Barbatia (*Cucullaearca*) *cliffensis* Hanna. Reinhart, 1943: 32–33, pl. 1, figs. 5–7. Moore, 1983:34–35, pl. 5, figs. 9, 12.

Primary Type Material. UCMP lectotype 31077, designated by Reinhart (1943:32), Ardath Shale, UCMP locality 5062.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. San Diego through Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 818?, 830? *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828.

Remarks. Only single specimens were found at each locality. Preservation is poor to fair. This species is characterized by the near central beaks, posterior umbone, and noded character of the ribs. Previously, this species had not been reported as ranging into the "Capay Stage" or as occurring in the Transverse Ranges of southern California.

Superfamily Limnopsacea

Family Glycymerididae Newton, 1922

Subfamily Glycymeridinae Newton, 1922

Genus *Glycymeris* da Costa, 1778

Type Species. By tautonymy, *Arca orbicularis* da Costa, 1778 [=*Arca glycymeris* Linné, 1758].

Subgenus *Glycymeris* s.s.

Glycymeris (*Glycymeris*) *rosecanyonensis* Hanna, 1927

Figure 90

Glycymeris rosecanyonensis Hanna, 1927:273–274, pl. 27, figs. 4–5, 9, 11. Clark, 1929:pl. 6, fig. 8. Givens and Kennedy, 1979:tables 1, 3.

Glycymeris (*Glycymeris*) *rosecanyonensis* Hanna. Givens, 1974:42. Moore, 1983:49–50, pl. 19, figs. 12–13. Squires, 1984:41, fig. 10c.

Glycymeris (*Glycymerita*) *rosecanyonensis* Hanna. Squires, 1977:table 1.

Primary Type Material. UCMP holotype 30989, Ardath Shale, UCMP locality 3990.

Molluscan Stage Range. "Domengine" through "Transition."

Geographic Distribution. San Diego through Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 363. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 237, 808.

Remarks. Only a few specimens were found at localities

363 and 808. Abundant specimens were found at locality 237, and they represent a growth series. Only single valves were found at all localities, and preservation is good.

Subgenus *Glycymerita* Finlay and Marwick, 1937

Type Species. By original designation, *Glycymeris concava* Marshall, 1917.

Glycymeris (*Glycymerita*) *sagittata* (Gabb, 1864)

Figure 91

Axinaea (*Limopsis*?) *sagittata* Gabb, 1864:197–198, pl. 31, figs. 267–267a.
Glycimeris hannibali Dickerson, 1916:483, pl. 36, figs. 8a–b.
Glycymeris sagittatus (Gabb). Dickerson, 1916:pl. 36, figs. 5a–b.
Glycymeris sagittata (Gabb). Anderson and Hanna, 1925: 181–182, pl. 1, fig. 6. Stewart, 1930:71–73, pl. 12, fig. 10; 1946:pl. 12, fig. 3. Vokes, 1939:45–46, pl. 1, figs. 18–20. Weaver, 1943:54–55, pl. 9, figs. 17–18; pl. 11, fig. 15. Kleinpell and Weaver, 1963:196–197, pl. 28, fig. 10; pl. 29, figs. 1–2. Deméré, Sundberg, and Schram, 1979:pl. 1, figs. 1–2.
Glycimeris sagittatus (Gabb). Turner, 1938:43–44, pl. 6, figs. 1–3.
Glycymeris (*Glycymerita*) *sagittata* (Gabb). Givens, 1974: 42–43. Squires, 1977:table 1; 1984:42, fig. 10d. Moore, 1983:54–55, pl. 12, fig. 17.

Primary Type Material. ANSP lectotype 4422, designated by Stewart (1930:72), Tejon Formation, near Fort Tejon (N ½ of section 29, T 10 N, R 19 W, Kern County, California).

Molluscan Stage Range. "Capay" through "Tejon," Oligocene?.

Geographic Distribution. San Diego, California through southwestern Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 362?, 806, 807, 841. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 363. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. At all the localities, except 237, a few specimens (less than five) were found. At locality 237, ten specimens were found, and they represent a partial growth series with specimens ranging in height from 10 to 20 mm. Only single valves were found at all localities, and preservation is fair.

Order Mytiloida

Superfamily Mytilacea

Family Mytilidae Rafinesque, 1815

Genus *Brachidontes* Swainson, 1840

Type Species. By monotypy, *Modiola sulcata* Lamarck, 1819 (not 1805) [=*Mytilus citrinus* Röding, 1798, =*Arca modiolus* Linné, 1767].

Subgenus *Brachidontes* s.s.

Brachidontes (*Brachidontes*) *cowlitzensis* (Weaver and Palmer, 1922)

Figure 92

Modiola ornata Gabb, 1864:184–185, pl. 24, fig. 166.
Not Mytilus ornatus Orbigny, 1843:283, pl. 342, figs. 10–12.
Modiolus ornatus Gabb. Arnold, 1907:pl. 38, fig. 4.
Modiolus (*Brachydontes*) *cowlitzensis* Weaver and Palmer, 1922:16–17, pl. 9, fig. 19 [new name for *Modiola ornata* Gabb, 1864, preoccupied].
Brachydontes ornatus (Gabb). Anderson and Hanna, 1925: 188, pl. 3, fig. 4.
Modiolus (*Brachydontes*) *ornatus* Gabb. Clark and Woodford, 1927:89, pl. 14, fig. 10. Clark, 1929:pl. 3, fig. 6.
Brachidontes cowlitzensis? (Weaver and Palmer). Stewart, 1930:100–103, pl. 8, fig. 12.
Brachidontes cowlitzensis (Weaver and Palmer). Turner, 1938: 45–46, pl. 6, figs. 7–8. Kleinpell and Weaver, 1963:197, pl. 29, fig. 3. Wolfe, 1977:3. Givens and Kennedy, 1979: table 2.
Volsella (*Brachidontes*) *cowlitzensis* (Weaver and Palmer). Weaver, 1943:113–114, pl. 26, fig. 4.
Brachidontes (*Brachidontes*) *cowlitzensis* (Weaver and Palmer). Givens, 1974:43. Squires, 1977:table 1; 1984:42, fig. 10c. Moore, 1983:66–67, pl. 17, fig. 1.

Primary Type Material. ANSP lectotype 4450 of *Modiola ornata* Gabb, designated by Stewart (1930:101), Domengine? Formation, Martinez, California. CAS holotype 7406 of *Modiolus* (*Brachydontes*) *ornatus* Weaver and Palmer, Cowlitz Formation, UW locality 329.

Molluscan Stage Range. "Meganos" through lower Oligocene (*Turritella variata lorenzana* Zone of Kleinpell and Weaver, 1963).

Geographic Distribution. San Diego, California through Gulf of Alaska.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 358. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 237, 808?

Remarks. One internal mold was found at each of the localities. An additional well-preserved specimen (Fig. 92) was found at locality 237. All specimens show the subterminal beak and high umbonal fold so characteristic of this species.

Genus *Septifer* Récluz, 1848

Type Species. By subsequent designation (Stoliczka, 1871), *Mytilus bilocularis* Linné, 1758.

Subgenus *Septifer* s.s.

Septifer (*Septifer*) cf. *S.* (*S.*) *elegans* Waring, 1917

Figure 93

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 364, 813.

Remarks. Seven specimens were found at locality 364, and one specimen was found at locality 813. All the specimens are internal molds of single valves. They have a subquadrate outline, with the anterior side abruptly truncated, and the rest of the shell is broad, moderately convex, and covered with strong radial ribs. The specimens most closely resemble *Septifer* (*Septifer*) *elegans* Waring (1917:79, pl. 14, fig. 2; Moore, 1983:70, pl. 18, fig. 11) from Paleocene and possibly Eocene strata, Simi Valley, southern California. The exact location of the type locality of *S.* (*S.*) *elegans* is unknown and probably never will be known. It is important to mention also that the holotype of *S.* (*S.*) *elegans* is an internal mold.

The Whitaker Peak specimens superficially resemble *Brachidontes* (*Brachidontes*) *cowlitzensis* (Weaver and Palmer), but they lack the subterminal beak and high umbonal fold so characteristic of that species.

Order Pterioida

Suborder Pteriina

Superfamily Pectinacea

Family Propeamussiidae Abbott, 1954

Propeamussiidae, indet.

Figure 94

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 362.

Remarks. Only a single specimen was found, and it is a smooth internal mold that retains no shell. Presumably, it is a right valve. The posterior? auricle is squarely truncated. The anterior? auricle is incomplete. Due to poor preservation, generic identification is not possible, but the outline of the auricles and the lack of any trace of internal ribs suggest *Cyclopecten*. Only one West Coast species, *Cyclopecten*? *martinezensis* (Gabb, 1869:198, pl. 33, fig. 96; Stewart, 1930: 117–118, pl. 7, fig. 10; Moore, 1984:8–9, pl. 1, figs. 9, 10) from the Paleocene Martinez Formation, central California, has been assigned to this genus. The Whitaker Peak specimen is similar in outline but shows no trace of the fine radial ribs that are present near the ventral margin on the internal mold of the lectotype of *C.* ? *martinezensis*.

The Whitaker Peak propeamussid specimen is of "Capay Stage" age, but the only other West Coast "Capay Stage" propeamussid, *Propeamussium interradiatum* (Gabb, 1869: 199–200, pl. 33, fig. 98, not? fig. 98a) from the Capay and other formations of central California (Moore, 1984), has large internal radial ribs. See Moore (1984) for a discussion and updated synonymy of *P. interradiatum*.

Another propeamussid that is probably about the same geologic age as the Whitaker Peak specimen is *Parvamussium mideocenicum* (Vokes, 1939:55–56, pl. 3, figs. 2, 3, not? pl. 3, fig. 4; Moore, 1984:9, pl. 1, fig. 11) from the Cerros Shale Member of the Lodo Formation, UCMP locality 1817, central California. See "Remarks" for *Turritella andersoni* in this present report for a discussion of the age of this locality. *Parvamussium mideocenium* has well-developed internal ribs; therefore, it is distinctly different from the Whitaker Peak specimen.

The classification system of Waller (1978) is used for the propeamussiid rather than the system of Hertlein (1969), which was adopted by Vokes (1980). Moore (1984) also used Waller's system because the shell microstructure and soft-part anatomy provide ample evidence for the separation of the Propeamussiidae from the Pectinidae.

Family Plicatulidae Watson, 1930

Genus *Plicatula* Lamarck, 1801

Type Species. By subsequent designation (Schmidt, 1818), *Spondylus plicatus* Linné, 1758.

Plicatula juncalensis new species

Figures 95, 96

Diagnosis. Generic assignment based on ostreiform shape, equivalved and inequilateral shell, attached right valve (beak area), short hinge with two small teeth on each side of a shallow resilium pit, internally tuberculate valve margins, and external ornamentation of bifurcating radial ribs. Specific assignment based on scaly-nodose secondary radial ribs in interspaces between primary radial ribs.

Plicatula juncalensis new species is most similar to *Plicatula parisiensis* Deshayes (1864:87, pl. 80, figs. 5–7; Cossmann and Pissarro, 1904–1906:pl. 41, fig. 133-6) from middle and upper Eocene strata (Lutetian and Bartonian stages) of the Paris Basin, France (Chédeville, 1902:229). According to Chédeville (1902:229), *P. parisiensis* = *P. condylus* Deshayes (1864:88, pl. 80, figs. 11–13), and Cossmann and Pissarro (1904–1906:pl. 41, fig. 133-6′) considered *P. condylus* to be a variety of *P. parisiensis*. *Plicatula juncalensis* new species differs from examined specimens of *P. parisiensis* (regarded as synonymous with *P. condylus* in this present report) in the following features: presence of scaly-nodose (beaded appearance) secondary radial ribs in interspaces between primary radial ribs, less elevated primary radial ribs, four more primary radial ribs on right valve, and absence of spines on primary radial ribs along valve margin.

Plicatula juncalensis new species is similar to *Plicatula filamentosa planata* Meyer and Aldrich (1886:45, pl. 2, fig. 20; Dockery, 1980:pl. 23, fig. 6; pl. 48, figs. 1–3) from middle Eocene strata of Mississippi and Louisiana (Palmer and Brann, 1965). *Plicatula juncalensis* differs from *P. filamentosa planata* in the following features: shell more oblique, unequal number of primary radial ribs, and an absence of spines.

Plicatula ostreiformis Stanton (1896:1038, pl. 63, figs. 5, 6) is the only other reported species of *Plicatula* from the West Coast Tertiary, and it is from Paleocene strata of Lake County, northern California. *Plicatula juncalensis* new species differs greatly from *P. ostreiformis* in the following features: shell more oblique and not as thick or as large, left valve not concave in the middle, and sculpture much more strongly developed.

Description. Shell small, ostreiform, slightly oblique, inequilateral, and equivalved with same degree of convexity.

Valve margins plicate, no byssal sinus. Right valve shows small area of attachment in dorsal-posterior beak region. Left valve has an inflated beak with prominent callosity. Shell sculpture of closely spaced primary radial ribs (some bifurcate) with up to five intervening secondary ribs. Right valve with up to 24 primary radial ribs (includes bifurcating ribs). Left valve with up to 17 primary radial ribs (includes bifurcating ribs). Primary ribs commarginally lamellose, and secondary radial ribs commarginally scaly and/or noded (i.e., beaded appearance).

Hinge short, valves with two small teeth on each side of a shallow resilium pit. Widely spaced tubercles along valve margin interiors near hinge.

Length of holotype (complete) 15 mm, height (complete) 18.5 mm.

Primary Type Material. LACMIP holotype 7513, Juncal Formation, CSUN locality 362.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 362, 830.

Remarks. Twenty-one specimens were found. All but one are from locality 830. Four specimens are articulated, and nearly all the others are left valves. The holotype (Figs. 95, 96) is the largest and best preserved specimen. At locality 830, the specimens are poorly preserved. Internal details are difficult to study due to the well-indurated nature of the matrix.

Plicatula ranges from Middle Triassic (Ladinian Stage) through Holocene (Cox and Hertlein, 1969; Davies, 1971). West Coast Cretaceous species (Anderson, 1938) are markedly different than *P. juncalensis* new species as is the only reported West Coast Paleocene species; namely, *P. ostreiformis* Stanton (1896) from "Martinez Stage" strata in northern California. *Plicatula juncalensis* is the first described species of *Plicatula* from the West Coast Eocene. Page, Marks, and Walker (1951:1754) and Dibblee (1966:24) noted *Plicatula* sp. from the basal calcareous sandstone bed in the lower shale strata of the lower Eocene Juncal Formation at the type section of that formation east of Agua Caliente Canyon, central Santa Ynez Mountains, Santa Barbara County, California. According to Dibblee (1966), this bed is probably equivalent to the Sierra Blanca Limestone. Van de Kamp et al. (1974) assigned the Sierra Blanca Limestone to early Eocene time. An attempt to find the specimen(s) in the Stanford University collections, now at the California Academy of Sciences, was unsuccessful.

Etymology. The species is named for the Juncal Formation.

Suborder Ostreina

Superfamily Ostreacea

Family Ostreidae Rafinesque, 1815

Subfamily Ostreinae Rafinesque, 1815

Genus *Ostrea* Linné, 1758

Type Species. By subsequent designation (ICZN opin. 94 and 356). *Ostrea edulis* Linné, 1758.

Ostrea haleyi Hertlein, 1933

Figure 97

Ostrea haleyi Hertlein, 1933:277–281, pl. 18, figs. 5–6. Zinsmeister, 1983b: 1286–1287.

Odontogryphaea? haleyi (Hertlein). Givens, 1974:45, pl. 1, figs. 11–13. Squires and Advocate, 1986:852.

Primary Type Material. CAS holotype 5526, SDNHM plastoholotype 426, SDNHM paratype 427, Domengine Formation, Cañada del Pozo, Santa Cruz Island, Santa Barbara County, California.

Molluscan Stage Range. "Capay."

Geographic Distribution. Orocopia Mountains, Riverside County, through Transverse Ranges, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 362, 818, 819, 827, 845.

Remarks. Six specimens were found at locality 845, and one to two specimens were found at the other localities. All the specimens consist of fragmental gryphaeoid-shaped left valves. Those at locality 845 are less inflated than elsewhere. None of the specimens at any locality shows any indication of the presence of a terebratuloid fold in the valve commissure, which is characteristic of the genus *Odontogryphaea*. Until specimens are found that prove that this species belongs to *Odontogryphaea*, it seems best to follow the work of Zinsmeister (1983b) and reassign this species to *Ostrea*. Zinsmeister (1983b), furthermore, suggested that the late Paleocene *Ostrea simiensis* Zinsmeister from Simi Valley, southern California, might be ancestral to the Eocene *Ostrea haleyi* Hertlein.

Ostrea stewarti Hanna, 1927

Figure 98

Ostrea stewarti Hanna, 1927:276, pl. 28, fig. 1; pl. 29, fig. 3, pl. 30, fig. 3. Squires, 1977:table 1.

Primary Type Material. UCMP syntypes 30921–30922, Ardath Shale, UCMP locality 5062.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego through Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 28, 81, 214, 216, 220, 246.

Remarks. Abundant disarticulated specimens of *O. stewarti* were essentially the only fossils found at localities 28, 81, 214, and 220. As noted in Squires (1977), all of the specimens from these localities occur as float material, but the specimens are too abundant, too well preserved, and too predictable in their occurrence to have been derived from another rock unit. A single, large (length 97 mm), complete specimen of *O. stewarti* was the only fossil found at locality 216.

This species, which can be large, is characterized by thick valves (especially the left or lower valve), fairly straight beaks, a nearly central adductor muscle scar that is circular to subcircular in shape, left-valve hinge with an elongate central depression flanked by two raised ridges, and a right-valve hinge with an elongate central resilifer flanked by two grooves.

Prior to the report (Squires, 1977) of *Ostrea stewarti* in the Whitaker Peak area, this species had only been reported from the San Diego area (Hanna, 1927).

Ostrea cf. *O. stewarti* Hanna, 1927

Figure 99

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 360, 364.

Remarks. Several large fragments (up to 90 mm height) of thick-walled valves (up to 25 mm) were found at locality 364. Only one fragment was found at locality 360. Due to the fragmentary nature of the specimens, a positive species identification could not be made. The specimens resemble *O. stewarti* in their large size and very thick walls. The only specimen that shows the ligamental area is illustrated in Figure 99. This specimen is presumably a left valve with a very massive and nearly flattened ligamental area. There is only a slight depression in the central area. If, upon future collecting, these specimens prove to be *O. stewarti,* they would extend the molluscan stage range of this species into the "Capay Stage."

Subclass Heterodonta

Order Veneroida

Superfamily Lucinacea

Family Lucinidae Fleming, 1828

Subfamily Milthinae Chavan, 1969

Genus *Miltha* H. and A. Adams, 1857

Type Species. By original designation, *Lucina childreni* Gray, 1825.

Miltha packi (Dickerson, 1916)

Figure 100

Lucina packi Dickerson, 1916:484, pl. 36, fig. 12. Turner, 1938:52, pl. 9, fig. 11. Weaver, 1943:147, pl. 34, fig. 19, pl. 38, fig. 13.

Miltha (*Eomiltha*?) *packi* (Dickerson). Vokes, 1939:72, pl. 10, figs. 8, 12.

Miltha packi (Dickerson). Vokes, 1969:113. Givens and Kennedy, 1979:table 3. Deméré, Sundberg, and Schram, 1979:pl. 1, figs. 10–11.

Primary Type Material. UCMP holotype 11787, Domengine Formation, UCMP locality 672.

Molluscan Stage Range. "Capay" through "Tejon."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 362, 805, 806, 830, 844, 845?, 850.

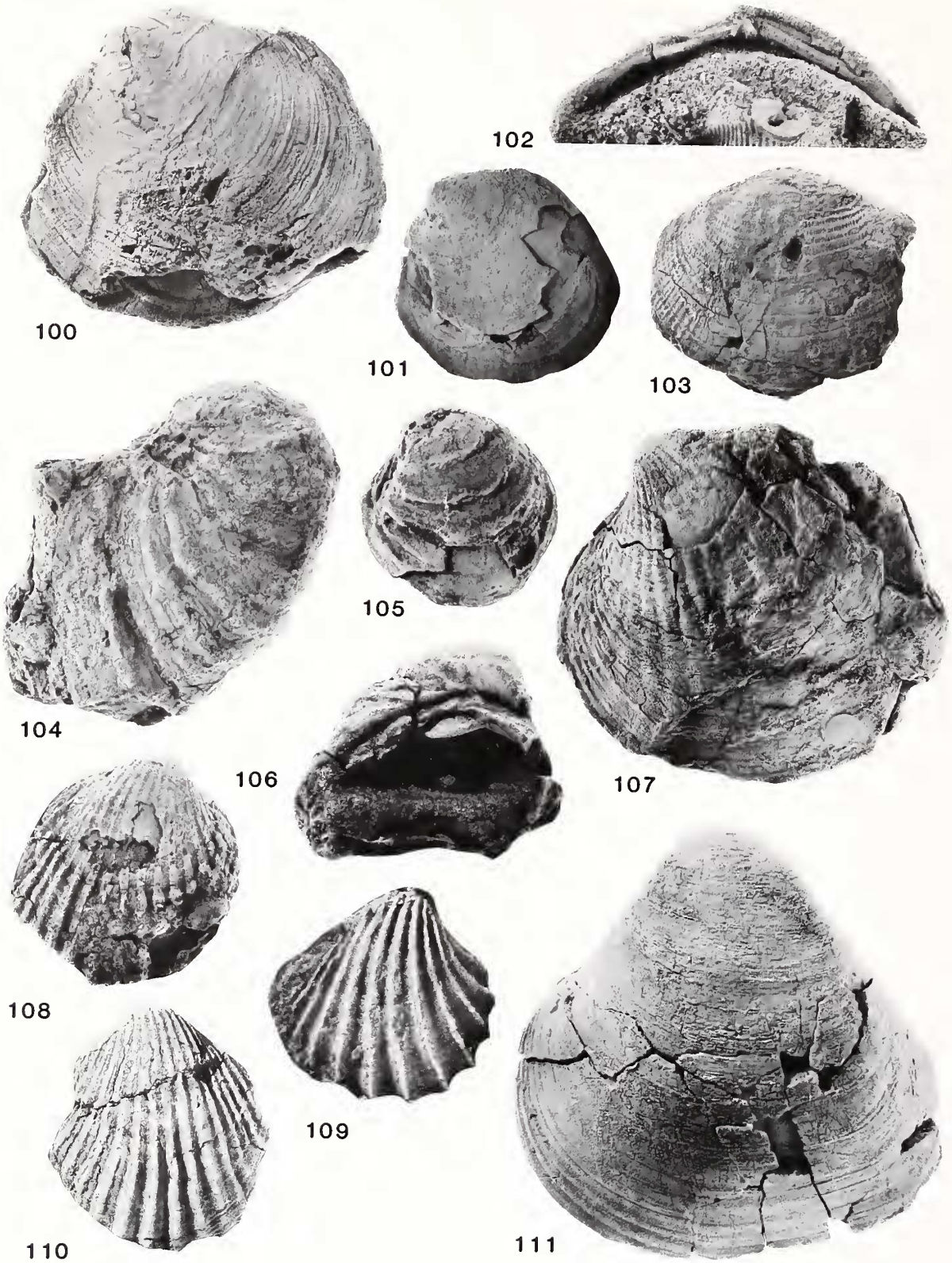
Remarks. This species is uncommon, but not rare, in the Whitaker Peak area. It is confined to *Turritella uvasana infera*-fauna strata between Sharps Canyon and Canton Canyon. Only one or two specimens were found at each locality where it occurs, and nearly all the specimens are large to very large in size (39 to 115 mm height). The specimens are nearly all articulated and show poor to fair preservation, except at localities 806 and 830 where there are large fragments of the shell surrounded by much carbonized wood. The smallest (single valve) and largest (articulated) specimens were found at locality 358.

Dickerson's (1916) type is an immature specimen (8 mm height), as noted by Vokes (1939). The Whitaker Peak specimens, therefore, agree more with Turner's (1938) illustration and Vokes' (1939) description of adult specimens. The Whitaker Peak adult specimen is characterized by mostly large circular valves with fine commarginal ribbing with areas where the ornamentation can be faint, nearly central prosogyrous beaks, and two shallow posterior grooves parallel to and just below the posterior margin. The smaller specimens have the coarsest commarginal ribbing. Vokes (1939) mentioned that his Coalinga, California, specimens have two posterior grooves, as well as an anterior groove. Turner's (1938:pl. 9, fig. 11) illustration of a Llajas Formation, Simi Valley, southern California, specimen also shows two posterior grooves. In most of the Whitaker Peak specimens there is a problem with preservation, and usually only one posterior groove and only a very faint hint of an anterior groove are present, as in the case of the specimen illustrated in Figure 100.

A few left valves of the Whitaker Peak specimens show poorly preserved hinge-line details. There are two small cardinal teeth and a large nymph. There is also a fairly deep groove on the inner surface of these valves that extends from the middle of the dorsal posterior region to the anterior ventral region. These features have been illustrated by Vokes (1939:pl. 10, fig. 12).

Vokes (1939) assigned this species to *Miltha* (*Eomiltha*?). The species does agree closely with the diagnosis of genus *Miltha* given by Bretsky (1976:239). Although the Whitaker Peak specimens are relatively poorly preserved, they show no features that counter an assignment to *Miltha*. Assignment to *Eomiltha,* however, does not seem justified because according to Bretsky (1976) *Eomiltha* is elongate anteroposteriorly, has a short ligament, and seemingly has three cardinal teeth. None of these features is present on the West Coast specimens of *Miltha packi* that show the hinge line. Assignment of *Miltha packi* to any subgenus seems inappropriate at this time, until better preserved specimens are found that show anterior muscle scars, lunule areas, and ventral internal margins.

Previously, this species had not been reported with certainty as ranging into the "Capay Stage." Givens (1974:table 1) reported large, poorly preserved specimens of *Miltha* cf.



Figures 100–111. Whitaker Peak area Eocene bivalves. **100.** *Miltha packi* (Dickerson, 1916), left valve, ×0.8, length 76 mm, height 68 mm, LACMIP hypotype 7571, CSUN loc. 362. **101–102.** *Claibornites diegoensis* (Dickerson, 1916). **101.** Left valve, ×1, length 34 mm, height 37 mm, LACMIP hypotype 7518, CSUN loc. 358. **102.** Right valve hinge line, ×2.2, length 29 mm, height 4 mm, LACMIP hypotype 59281

M. packi (Dickerson) from "Capay" through "Transition" "stages" in the Pine Mountain area, southern California.

Claibornites diegoensis (Dickerson, 1916)

Figures 101, 102

Lucina diegoensis Dickerson, 1916:484, pl. 37, figs. 1a–b.
Claibornites diegoensis (Dickerson). Givens, 1974:45–46, pl. 1, fig. 15. Squires, 1984:45, fig. 10m.

Primary Type Material. UCMP holotype 11788, Ardath Shale, UCMP locality 2226.

Molluscan Stage Range. "Capay" through "Domengine."

Genus *Claibornites* Stewart, 1930

Type Species. By original designation, *Lucina rotunda* Lea, 1833.

Geographic Distribution. San Diego through Pine Mountain area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 358.

Remarks. Only a single valve was found. This species is characterized by an orbieular-shaped shell with central prominent beaks, a feeble umbonal groove in the dorsal posterior region, and fairly strong, very closely spaced commarginal ribbing. The hinge line, which is illustrated for the first time in Figure 102, is that of a right-valve hinge line on a specimen (UCLA hypotype 52981) from CSUN locality 374, from the "Domengine Stage" portion of the Llajas Formation, Simi Valley, southern California (Squires, 1984:45, fig. 10m). The hinge has two narrow eardinals in each valve with the right posteriormost one slightly bifid. A single anterior and no (obsolete?) posterior lateral teeth were observed in the better preserved right-valve specimen. Two poorly preserved anterior lateral teeth were observed in the left valve. The ligament groove is wide and deeply inset in the right valve and narrow in the left valve. The nymph in the left valve is very thick and swollen laterally. It must take up a large portion of the ligament groove area of the right valve when the valves are together.

Based on figures only, Stewart (1930:184) tentatively assigned *Lucina diegoensis* Dickerson to *Claibornites*. According to Bretsky (1976:287), the shell interior of this species was unknown to Stewart (1930). Givens (1974:45–46) made Stewart's assignment definite.

Previously, this species had not been reported as ranging into the "Capay Stage."

Family Fimbriidae Nicol, 1950

Genus *Fimbria* Megerle, 1811

Type Species. By original designation, *Fimbria magna* Megerle, 1811 [=*Venus fimbriata* Linné, 1758].

Fimbria new species?

Figure 103

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 830.

Remarks. Only one specimen was found, and it is an incomplete left valve. Preservation is poor to fair. Hinge-line details are very poorly preserved. This specimen has a prominent cancellate sculpture pattern except in the middle portion of the shell. Its absence there may be due to poor preservation. Due to the poor preservation and incompleteness, a specific identification cannot be made at this time. The specimen may be a new species, as *Fimbria* [=*Corbis*] is rare in West Coast strata, and this specimen is unlike any described West Coast species.

Three specimens of *Fimbria* new species were reported by Dawson (1978:54–55, pl. 1, Figs. 15–17) from the Upper Cretaceous (Maestrichtian) Cabrillo Formation, San Diego, California. *Fimbria* new species? from the Whitaker Peak area is more inequilateral and has much stronger radial and commarginal ribs than the *Fibria* from the Cabrillo Formation.

Nelson (1925:402) and Davies (1975:157) mentioned that *Fimbria* occurs with *Velates* in the upper part ("Meganos Stage") of the Santa Susana Formation, Simi Valley, southern California. These strata are latest Paleocene/early Eocene in age (Filewicz and Hill, 1983). Saul (pers. commun.) has seen these specimens, but an attempt by the author to find them in the UCMP collections was unsuccessful.

Page, Marks, and Walker (1951:1754) and Dibblee (1966: 24) reported *Fimbria* sp. from the basal calcareous sandstone bed in the lower shale strata of the lower Eocene Juncal Formation at the type section area of that formation east of Agua Caliente Canyon, central Santa Ynez Mountains, Santa Barbara County, California. According to Dibblee (1966),

---

←

(formerly UCLA hypotype 59281), CSUN loc. 374 (Llajas Formation, Simi Valley, California). **103.** *Fimbria* new species?, left valve, ×1, length 45 mm, height 40 mm, LACM1P hypotype 7519, CSUN loc. 830. **104–106.** *Chama piruensis* new species. All parts left valves. **104.** ×1.7, length 34 mm, height 33 mm, LACM1P holotype 7520, CSUN loc. 822. **105.** Juvenile, ×2, length 16.5 mm, height 17 mm, LACM1P paratype 7521, CSUN loc. 834. **106.** Hinge line, ×1.9, length 24 mm, height 19 mm, LACM1P paratype 7522, CSUN loc. 844. **107.** *Venericardia* (*Pacificor*) *hornii lutmani* Turner, 1938, left valve, ×0.8, length 76 mm, height 82 mm, LACM1P hypotype 7524, CSUN loc. 824. **108.** *Venericardia* (*Pacificor*) *aragonia joaquinensis* (Vokes, 1939), right valve, ×1.6, length 22, height 25, LACM1P hypotype 7525, CSUN loc. 815. **109.** *Glyptoactis* (*Glyptoactis*) *domenginica* (Vokes, 1939), right valve, ×4, length 9 mm, height 9 mm, LACM1P hypotype 7526, CSUN 828. **110.** *Glyptoactis* (*Claibornicardia*) *sandiegoensis* (Hanna, 1927), left valve, ×1.6, length 22 mm, height 25 mm, LACM1P hypotype 7527, CSUN loc. 844. **111.** *Crassatella uvasana* Conrad, 1855, left valve, ×0.8, length 89 mm, height 90 mm, LACM1P hypotype 7528, CSUN loc. 237.

this bed is probably equivalent to the Sierra Blanca Limestone. Van de Kamp et al. (1974) assigned the Sierra Blanca Limestone to early Eocene time. An attempt to find the specimen(s) in the Stanford University collections, now at the California Academy of Sciences, was also unsuccessful.

Fimbria new species from the Whitaker Peak area is very different from the only described Eocene species of *Fimbria* from the West Coast; namely, *Fimbria mclellani* (Hanna, 1927:283, pl. 37, figs. 3–6) from middle Eocene strata, San Diego, California. *Fimbria mclellani* is a very small species with ten, widely spaced, very prominent and sharp commarginal ribs.

Fimbria new species? from the Whitaker Peak area is very similar to *Fimbria olssoni* Richards and Palmer (1953:51, pl. 11, fig. 1) from the upper middle Eocene Avon Park Limestone, Florida. This similarity is striking, and it may be that the two are conspecific. Complete specimens of *F.* new species? will be necessary before this determination can be made satisfactorily.

Fimbria new species? from the Whitaker Peak area is also similar to *Fimbria jamaicensis* (Trechmann, 1923:364, pl. 18, fig. 5) from the middle Eocene Yellow Limestone, Jamaica. *Fimbria* new species?, however, has stronger radial ribs on the ventral margin.

Superfamily Chamacea

Family Chamidae Lamarck, 1809

Genus *Chama* Linné, 1758

Type Species. By subsequent designation (Schmidt, 1818), *Chama lazarus* Linné, 1758.

Chama piruensis new species

Figures 104–106

Diagnosis. Generic assignment based on spirally coiled, inflated left valve, prosogyrate, ligament external, anterior cardinal large and solid, posterior cardinal slender, long, and curved. Ornament commarginal and irregularly lamellate. Specific assignment based on strongly spirally coiled, very elongate left valve covered with irregularly spaced commarginal lamellae.

Chama piruensis new species is similar to *Chama calcarata* Lamarck (1806:349; 1809:pl. 23, figs. 4a, b; Deshayes, 1825: 246–247, pl. 38, figs. 5–7; 1860:583; Wood, 1871:172–173, pl. 25, figs. 1a–c; Chédeville, 1901:122; Cossmann and Pissarro, 1904–1906:pl. 20, fig. 76-5; Kennedy, Morris, and Taylor, 1970:390, pl. 72, figs. 2a, b; Pomerol and Feugueur, 1974:pl. 8, fig. 4) from middle and upper Eocene strata (Lutetian and Bartonian stages) of the Anglo-Paris Basin. *Chama piruensis* differs from several examined left valves of *C. calcarata* in the following features: less inflated middle portion of the valve, more irregularly spaced commarginal lamellae, and absence of radial ribs. In addition, *C. piruensis* shows no tendency for development of spines on the commarginal lamellae along margins of the left valve. The lack of such spines on *C. piruensis,* however, may be due to poor preservation. Presence of such spines is not a constant feature of *C. calcarata,* based on an examination of specimens from the Los Angeles County Museum collection.

Description. Young individuals (up to 20 mm height) are nearly equivalved and circular, with left valve somewhat more inflated. No attachment scar visible. Prosogyrate beaks opposite each other, lunule moderately well defined. Commarginal lamellae are widely but irregularly spaced (approximately 3 to 7 mm apart), and on right valve numerous very fine commarginal threads occur between these lamellae.

Only left valves of adult specimens were found. Left valve strongly spirally coiled, inflated, and very elongate. No attachment scar visible. Beak prosogyrate. Ligamental area external, opisthodetic, long, and moderately grooved. Anterior cardinal large and solid; posterior cardinal slender, long, and curved. Ornament commarginal and very irregularly lamellate. Lamellae usually 2 to 3 mm apart but can be up to 5 mm. Length of holotype (incomplete) 34 mm, height (incomplete) 33 mm.

Primary Type Material. LACMIP holotype 7520, CSUN locality 844; LACMIP paratype 7521, CSUN locality 844; LACMIP paratype 7522, CSUN locality 834; LACMIP paratype 7523, CSUN locality 822; all from Juncal Formation.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 822, 831, 834, 844, 845.

Remarks. Specimens of this new species are fairly uncommon in the Whitaker Peak section. Only 16 specimens were found and 12 are small fragments. Ten specimens were found at locality 844, three at locality 822, and one at each of the other localities. Preservation is fair but the siltstone matrix adheres strongly to the specimens. At locality 844, the specimens were found in close proximity to the coral *Astrocoenia* new species? aff. *A. portoricoensis.*

Chama ranges from Late Cretaceous (Cenomanian) through Holocene. The first authenticated *Chama* is from Austria. Little is known of *Chama* in Paleocene strata, but it becomes much more common in the Eocene with numerous species, especially in the Anglo-Paris Basin (Kennedy, Morris, and Taylor, 1970; Bernard, 1976).

Palmer and Brann (1965) recorded one species of *Chama* from Paleocene strata of Georgia, three species from middle Eocene strata of Mississippi and Alabama, and four species from upper Eocene strata of the southeastern United States. Prior to the discovery of *C. piruensis* new species, the earliest known occurrence of *Chama* on the West Coast of North America was *Chama* new species Loel and Corey, 1932, from the upper Oligocene through lower Miocene Vaqueros Formation, at Torrey Canyon, Oak Ridge, southern California. *Chama piruensis* new species, therefore, extends the earliest occurrence of *Chama* on the West Coast to the early Eocene.

The work by Kennedy, Morris, and Taylor (1970) shows that the superfamily Chamacea can be considered now as a homogeneous group, distinct from other cemented bivalves such as the rudists and certain pandoraceans. Subgenera proposed by Keen (1969) for *Chama,* such as *Cipliacella* and

Psilopus, are not recognized in this present report because according to Bernard (1976) sueh subgenera are based upon minor variations not significant above the species level.

Etymology. The species is named for Piru Creek, southern California.

Superfamily Carditacea

Family Carditidae Fleming, 1820

Subfamily Venericardiinae Chavan, 1969

Genus *Venericardia* Lamarck, 1801

Type Species. By subsequent designation (Schmidt, 1818), *Venericardia imbricata* Lamarck, 1801.

Subgenus *Pacificor* Verastegui, 1953

Type Species. By original designation, *Venericardia* (*Pacificor*) *mulleri* Verastegui, 1953.

Venericardia (*Pacificor*) *hornii lutmani* Turner, 1938

Figure 107

Venericardia hornii lutmani Turner, 1938:50, pl. 13, fig. 4; pl. 14, fig. 2. Weaver, 1943:135, pl. 28, fig. 1; pl. 32, fig. 1.
Venericardia (*Pacificor*) *lutmani* Turner. Verastegui, 1953: 26–27, pl. 7, figs. 3–5; pl. 8, fig. 8.
Venericardia (*Pacificor*) *hornii lutmani* Turner. Givens, 1974: 47, pl. 1, fig. 16; pl. 2, fig. 8. Saul, 1983:pl. 2, fig. 6.

Primary Type Material. UCMP holotype 33133, UCMP locality A-1233; UCMP paratype 33134, UCMP locality A-1173, lower Umpqua Formation.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak and Pine Mountain areas, southern California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 824, 846?

Remarks. Only one specimen of this taxon that could be positively identified was found in the Whitaker Peak seetion. It is large (height 82 mm), articulated, and fairly well preserved. Five small, disarticulated specimens were found at locality 846. They are internal molds that show about 30 radial ribs on each valve. According to Givens (1974), this species is distinguished by 27 to 30 radial ribs.

Although Turner (1938) and Verastegui (1953) reported this species from the upper Paleocene "Santa Susana Shale" in Simi Valley, southern California, Saul (1983) reported that Turner's (1938:50) *V. hornii lutmani* from the "Santa Susana Shale" is undoubtedly *V.* (*P.*) *hornii susanaensis* Verastegui (1953:22–23), pl. 5, figs. 1–4). *Venericardia* (*P.*) *hornii lutmani* Turner has not been found in Simi Valley (Saul, 1983).

Venericardia (*Pacificor*) *aragonia joaquinensis* (Vokes, 1939)

Figure 108

Venericardia aragonia var. Turner, 1938:49, pl. 13, figs. 6–9.
Megacardita (*Venericor*) *hornii joaquinensis* Vokes, 1939: 69–70, pl. 8, figs. 1–2; pl. 9, figs. 1–2.
Venericardia (*Leuroactis*) *schencki* Verastegui, 1953:50–51, pl. 4, figs. 6–8.
Venericardia (*Leuroactis*) *alisoensis* Verastegui, 1953:52–53, pl. 10, figs. 1–3.
Venericardia (*Leuroactis*) *joaquinensis* (Vokes). Verastegui, 1953:60–61, pl. 11, figs. 1–4; pl. 12, figs. 4–6.
Venericardia (*Leuroactis*) *vokesi* Verastegui, 1953:61–62, pl. 14, figs. 1–3.
Venericardia (*Pacificor*) *aragonia joaquinensis* (Vokes). Saul, 1983:pl. 2, figs. 7–8. Squires, 1984:46, fig. 10p.

Primary Type Material. UCMP holotype 15616, UCMP locality 4170; UCMP paratype 15617, UCMP locality 4169; UCMP paratype 15618, UCMP locality A-819; all from Avenal Formation.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley, southern California through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 803, 806, 813, 815. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828?

Remarks. About seven small, disarticulated specimens were found at each locality, except at localities 815 and 828 where only single specimens were found. Preservation is poor with internal molds common. This subspecies is characterized by the presence of about 21 radial ribs.

The presence of *V.* (*P.*) *aragonia joaquinensis* in the *Turritella uvasana infera* fauna of the Whitaker Peak section extends the molluscan stage range of this subspecies into the "Capay Stage" proper. Previously, the lower range limit had been known to be uppermost "Capay" (Saul, 1983; Squires, 1984).

Subfamily Carditesinae Chavan, 1969

Genus *Glyptoactis* Stewart, 1930

Type Species. By original designation, *Venericardia hadra* Dall, 1903.

Subgenus *Glyptoactis* s.s.

Glyptoactis (*Glyptoactis*) *domenginica* (Vokes, 1939)

Figure 109

Venericardia (*Glyptoactis*?) *domenginica* Vokes, 1939:66, pl. 5, figs. 7–9.
Venericardia (*Glyptoactis*) *domenginica* Vokes. Verastegui, 1953:43–44, pl. 13, fig. 1.
Glyptoactis domenginica (Vokes). Givens, 1974:47. Squires, 1977:table 1. Givens and Kennedy, 1979:tables 1, 3.
Glyptoactis (*Glyptoactis*) *domenginica* (Vokes). Squires, 1984: 46–47, figs. 10r–q.

Primary Type Material. UCMP holotype 15611, Domen-

gine Formation, UCMP locality A-1219; UCMP paratypes 15612 and 15613, Tejon Formation, UCMP locality A-1003.

Molluscan Stage Range. "Domengine" through "Transition."

Geographic Distribution. San Diego through Mt. Diablo, northern California.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 232?, 237.

Remarks. Only two specimens were found at each locality. Preservation is poor to fair, and most of the specimens are internal molds. The best preserved specimen (Fig. 109) shows the characteristic noded tripartite ribs.

Subgenus *Claibornicardia* Stenzel and Krause, 1957

Type Species. By original designation, *Venericardia alticosta* Conrad, 1833.

Glyptoactis (*Claibornicardia*) *sandiegoensis* (Hanna, 1927)

Figure 110

Cardita sandiegoensis Hanna, 1927:283, pl. 37, figs. 1, 2, 8, 9.

Venericardia (*Glyptoactis*) *mcmasteri* Verastegui, 1953:42–43, pl. 13, figs. 2–3.

Glyptoactis (*Claibornicardia*) *sandiegoensis* (Hanna). Givens and Kennedy, 1979:95, table 1.

Primary Type Material. UCMP syntypes 30980-30983, Ardath Shale, UCMP locality 5062.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. San Diego through Whitaker Peak area, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 361?, 825, 835, 837, 844, 847.

Remarks. About four valves were found at each locality, except at localities 361 and 825 where only single valves were found. All specimens are poorly preserved except the slightly worn figured specimen (Fig. 110) which has sculpture that matches the description of *Glyptoactis mcmasteri,* a junior synonym of *G.* (*C.*) *sandiegoensis.*

Claibornicardia is characterized by tripartite radial ribs in the anterior part of the shell and simple radial ribs in the posterior part. Hanna (1927) reported that his species had 15 to 19 radial ribs. The Whitaker Peak specimens have 20 ribs.

Previously, this species had not been reported as ranging into the "Capay Stage" or found as far north as the Whitaker Peak area. These specimens in the Whitaker Peak area are the earliest occurrence worldwide referable to *Claibornicardia.*

Superfamily Crassatellacea

Family Crassatellidae Férussac, 1822

Subfamily Crassatellinae Férussac, 1822

Genus *Crassatella* Lamarck, 1799

Type Species. By subsequent designation (Schmidt, 1818), *Mactra cygnaea* Lamarck, 1799 (not Chemnitz, 1782) [=*C. gibba* Lamarck, 1801, =*Venus ponderosa* Gmelin, 1791].

Crassatella uvasana Conrad, 1855

Figure 111

Crassatella uvasana Conrad, 1855:9; 1857:pl. 2, fig. 5. Gabb, 1864:214–215, pl. 32, fig. 284. Stewart, 1930:141–143, pl. 12, fig. 9. Turner, 1938:47–48. Givens, 1974:48. Deméré, Sundberg, and Schram, 1979:pl. 1, fig. 7. Squires, 1984: 47–49, figs. 11a–g.

Crassatella alta Conrad, 1855:9; 1857:321 [not Conrad, 1832: 21, pl. 7].

Crassatella grandis Gabb, 1864:181, pl. 24, fig. 163; 1869: 189.

Astarte semidentata Cooper, 1894:48, pl. 3, figs. 44–45.

Crassatellites grandis (Gabb). Arnold, 1910:13, pl. 2, figs. 10–10a; pl. 3, fig. 14. Dickerson, 1915:80, pl. 1, fig. 8; pl. 2, figs. 1a–b [not Waring, 1917:74, pl. 12, fig. 16 = *Crassatella branneri fide* Nelson, 1925:410].

Crassatellites uvasana (Conrad). Arnold and Hannibal, 1913: 569. Dickerson, 1915:80, pl. 2, fig. 2. Waring, 1917:59, pl. 8, fig. 10.

Crassatellites mathewsonii (Gabb). Dickerson, 1916:pl. 36, figs. 9a–b (probably *C. semidentata* (Cooper) *fide* Turner, 1938:47–48).

Crassatellites uvasanus (Conrad). Anderson and Hanna, 1925: 172–174, pl. 4, figs. 2–3, text fig. 7.

Crassatellites semidentata (Cooper). Hanna, 1927:282, pl. 35, figs. 1–2.

Crassatella semidentata (Cooper). Turner, 1938:47–48.

Crassatella uvasana semidentata (Cooper). Vokes, 1939:64–65, pl. 4, figs. 4, 6, 8, 10, 12. Givens, 1974:48. Squires, 1977:table 1. Givens and Kennedy, 1979:tables 1, 3.

Crassatella uvasana uvasana (Conrad). Givens and Kennedy, 1979:table 4.

Primary Type Material. Holotype undetected, USNM collection, Tejon Formation, Grapevine Canyon, Tejon quadrangle, Kern County, California.

Molluscan Stage Range. "Domengine" through "Tejon."

Geographic Distribution. San Diego through central California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?.: CSUN localities 219, 231?, 237.

Remarks. Five left-hand valves and four right-hand valves were found at locality 237. Preservation is exeellent. A growth series is represented with a range of height from 14 to 90 mm. The juvenile specimens have higher and more prominent beaks than the adult specimens. This trend has been observed before in this species (Squires, 1984). Only single large valves were found at localities 219 and 231.

Superfamily Cardiacea

Family Cardiidae Lamarck, 1809

Subfamily Cardiinae Lamarck, 1809

Genus *Acanthocardia* Gray, 1851

Type Species. By subsequent designation (Stoliczka, 1870), *Cardium aculeatum* Linné, 1758.

Subgenus *Schedocardia* Stewart, 1930

Type Species. By original designation, *Cardium hatchetigbeense* Aldrich, 1886.

Acanthocardia (*Schedocardia*) *brewerii* (Gabb, 1864)

Figure 112

Cardium brewerii Gabb, 1864:173, pl. 24, fig. 155. Arnold, 1907:pl. 39, fig. 5. McLaughlin and Waring, 1915:fig. 14. Waring, 1917:pl. 14, fig. 9. Anderson and Hanna, 1925: 165–166, pl. 1, fig. 3. Clark, 1929:pl. 12, fig. 7.

Plagiocardium (*Schedocardia*) *brewerii* (Gabb). Stewart, 1930: 256–258, pl. 12, fig. 6. Turner, 1938:52–53, pl. 9, figs. 6–7. Vokes, 1939:75, pl. 11, figs. 1–4. Stewart, 1946:pl. 11, fig. 20.

Plagiocardium brewerii (Gabb). Merriam and Turner, 1937: table 2.

Loxocardium (*Schedocardia*) *brewerii* (Gabb). Weaver, 1943: 153–154, pl. 35, figs. 15–16, 18; pl. 38, figs. 1, 9; pl. 104, fig. 12.

Cardium (*Trachycardium*) *brewerii brewerii* (Gabb). Kleinpell and Weaver, 1963:201–202, pl. 34, figs. 1–2.

Acanthocardia (*Schedocardia*) *brewerii* (Gabb). Givens, 1974: 48–49, pl. 1, fig. 17. Squires, 1984:49, figs. 12a–b.

Acanthocardia brewerii (Gabb). Givens and Kennedy, 1979: table 4. Deméré, Sundberg, and Schram, 1979:pl. 2, fig. 10.

Primary Type Material. ANSP leetotype 4560, designated by Stewart (1930:257), Tejon Formation, east of north end of Grapevine Canyon, Kern County, California.

Molluscan Stage Range. "Capay" through "Tejon."

Geographic Distribution. San Diego, California through southwestern Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359, 807. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN localities 363, 828.

Remarks. Fifteen specimens were found at locality 358. At localities 359, 807, and 828, eight specimens were found. At locality 363, only one specimen was found. All specimens are single valves, and preservation is fair.

Subfamily Protocardiinae Keen, 1951

Genus *Nemocardium* Meek, 1876

Type Species. By subsequent designation (Sacco, 1899), *Cardium semiasperum* Deshayes, 1858.

Nemocardium linteum (Conrad, 1855)

Figure 113

Cardium linteum Conrad, 1855:3, 9; 1857:pl. 2, fig. 1. Anderson and Hanna, 1925:166–167, pl. 3, fig. 3.

Cardium cooperii Gabb, 1864:172, pl. 24, figs. 154–154a. Arnold, 1907:pl. 38, figs. 2–2a. Waring, 1917:pl. 13, fig. 3. Hanna, 1927:285, pl. 41, figs. 6–7.

Cardium dalli Dickerson, 1913:289, pl. 14, figs. 4a–c.

Not *Cardium dalli* Heilprin, 1887:131, pl. 16a, fig. 70.

Cardium marysvillensis Dickerson, 1916:482 [new name for *Cardium dalli* Dickerson, 1913, preoccupied].

Cardium (*Protocardium*) *marysvillensis* Dickerson. Clark and Woodford, 1927:94, pl. 15, fig. 12.

Nemocardium linteum (Conrad). Stewart, 1930:275–277, pl. 8, fig. 6. Turner, 1938:52, pl. 10, fig. 10. Vokes, 1939:76–77, pl. 11, figs. 6, 9. Weaver, 1943:159–160, pl. 38, fig. 3; 1953:28. Stewart, 1946:pl. 11, fig. 19. Moore, 1968:30, pl. 13d. Zinsmeister, 1974:97–98, pl. 9, figs. 7–9; 1983a:pl. 2, fig. 7. Givens and Kennedy, 1979:table 4. Squires, 1984: 49–50, fig. 12c.

Cardium (*Nemocardium*) *linteum* Conrad. Kleinpell and Weaver, 1963:202, pl. 34, fig. 4.

Nemocardium (*Nemocardium*) *linetum* (Conrad). Givens, 1974:49. Squires, 1977:table 1.

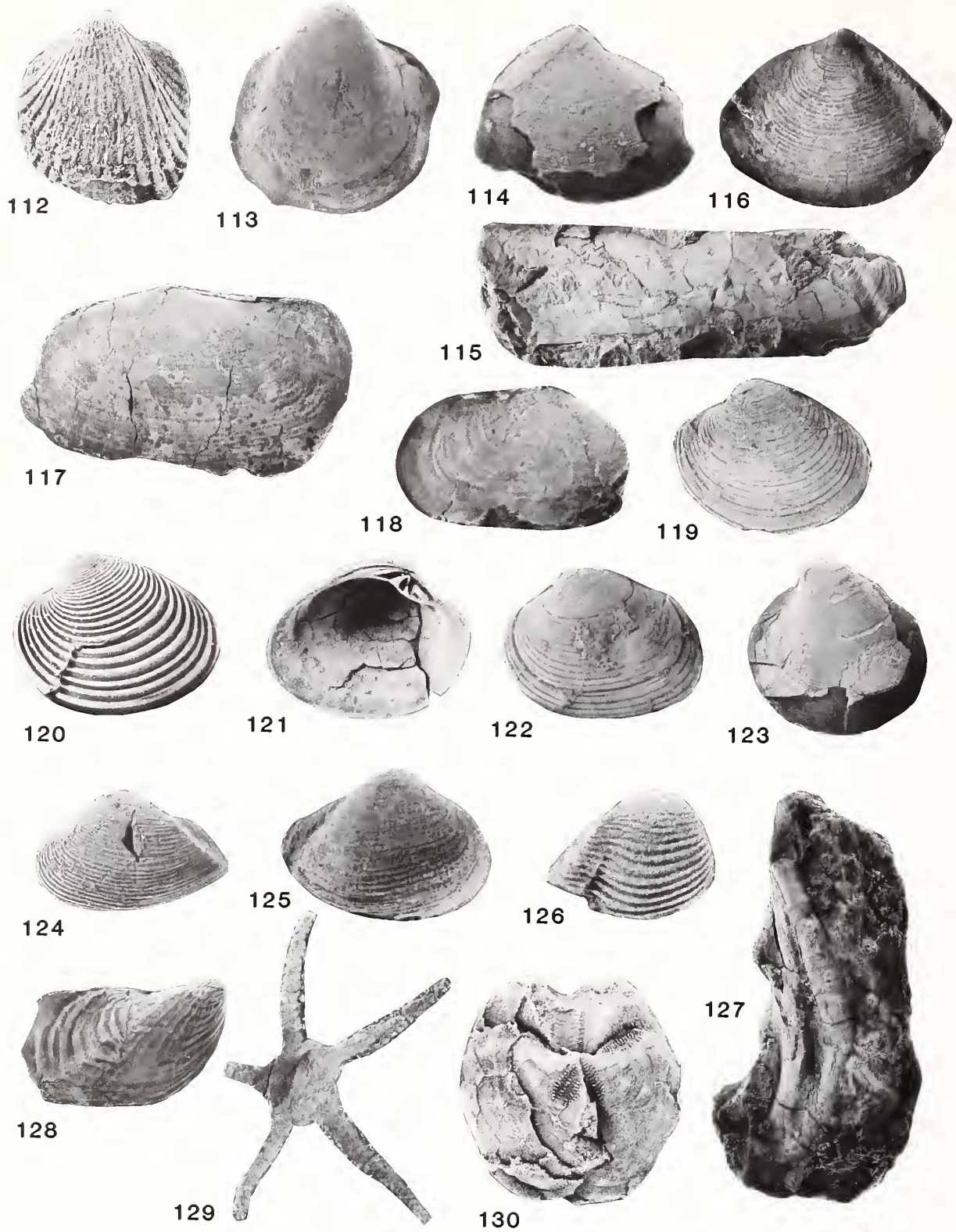
Primary Type Material. USNM holotype 1834, Domengine Formation near Martinez, California.

Molluscan Stage Range. "Martinez" through "Tejon."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 358. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 219, 232, 808.

Remarks. Three to four specimens were found at each of the *Turritella uvasana applinae* fauna localities whereas only single specimens were found at the *Turritella uvasana infera*



Figures 112–130. Whitaker Peak area bivalves, an ophiuroid, and an echinoid. **Figs. 112–128.** Bivalves. **112.** *Acanthocardia* (*Schedocardia*) *brewerii* (Gabb, 1864), left valve, ×2, length 14 mm, height 16.5 mm, LACMIP hypotype 7529, CSUN loc. 359. **113.** *Nemocardium linteum* (Conrad, 1855), mostly internal mold of right valve, ×1.7, length 21 mm, height 21, LACMIP hypotype 7530, CSUN loc. 232. **114.** *Spisula merriami* Packard, 1916, left valve, ×2.3, length 15 mm, height 13, LACMIP hypotype 7531, CSUN loc. 828. **115.** *Solena* (*Eosolen*) *novacularis*

fauna localities. Only single valves were found at all localities, and preservation is fair with internal molds common.

Superfamily Mactracea

Family Mactridae Lamarck, 1809

Subfamily Mactrinae Lamarck, 1809

Genus *Spisula* Gray, 1837

Type Species. By subsequent designation (Gray, 1837), "*Mactra solida* Montagu" [=*Cardium solidum* Linné, 1758].

Spisula merriami Packard, 1916

Figure 114

Spisula merriami Packard, 1916:294–295, pl. 27, figs. 3–4. Dickerson, 1916:485–486, pl. 39, figs. 2a–c. Vokes, 1939: 97, pl. 15, figs. 12–13. Weaver, 1943:233–234, pl. 52, figs. 11–12; p. 54, fig. 10.

Spisula cf. *merriami* Packard. Turner, 1938:64, pl. 6, fig. 12.

Primary Type Material. UCMP holotype 11484, UCMP paratype 11485, Domengine Formation, UCMP locality 672.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Whitaker Peak area, southern California through southwestern Oregon.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828.

Remarks. Only a single valve was found and preservation is fair. This species is characterized by a distinct ridge that extends posteriorly from the beak to the ventral margin and another ridge that extends anteriorly from the beak to the ventral surface. As Packard (1916) originally noted in his description, commarginal ribbing is present over the entire external shell surface. In the specimen from locality 828, ribbing is not preserved in the beak area, but elsewhere it is present.

Previously, this species had not been found south of the Coalinga area, central California.

Superfamily Solenacea

Family Solenidae Lamarck, 1809

Genus *Solena* Mörch, 1853

Type Species. By subsequent designation (Stoliczka, 1871), *Solen obliquus* Spengler, 1794.

Subgenus *Eosolen* Stewart, 1930

Type Species. By original designation, *Solen plagiaulax* Cossmann, 1906.

Solena (*Eosolen*) *novacularis* (Anderson and Hanna, 1928)

Figure 115

Solen novacula Anderson and Hanna, 1925:147, pl. 6, fig. 9. Hanna, 1927:294, pl. 43, fig. 1.

Not *Solen novacula* Montagu, 1803:47.

Solen novacularis Anderson and Hanna, 1928: 65–66 [new name for *Solen novacula* Anderson and Hanna, 1925, preoccupied].

Solena (*Eosolen*) *coosensis* Turner, 1938:62–63, pl. 9, figs. 1–2. Vokes, 1939:96, pl. 15, fig. 5. Givens, 1974:49–50, pl. 2, fig. 1.

Solena coosensis Turner. Weaver, 1943:229, pl. 52, fig. 16; pl. 53, fig. 13.

Solena novacularis (Anderson and Hanna). Givens and Kennedy, 1979:table 4.

Solena (*Eosolen*) *novacularis* (Anderson and Hanna). Squires, 1984:50, fig. 12d.

Primary Type Material. CAS holotype 882 of *Solen novacula* Anderson and Hanna and of *Solen novacularis* Anderson and Hanna, Tejon Formation, CAS locality 792.

Molluscan Stage Range. "Capay" through "Tejon."

←

(Anderson and Hanna, 1928), right valve, ×1.3, length 58 mm, height 19 mm, LACMIP hypotype 7532, CSUN loc. 827. **116.** *Tellina* (*Macaliopsis*) new species? aff. *T.* (*M.*) *rosa* (Hanna, 1927), partial internal mold of left valve, ×2, length 20 mm, height 15 mm, LACMIP hypotype 7533, CSUN loc. 845. **117.** *Gari texta* Gabb, 1864, mostly internal mold of left valve, ×1, length 55 mm, height 32 mm, LACMIP 7534, CSUN loc. 232. **118.** *Gari* new species? aff. *G. eoundulata* Vokes, 1939, internal mold of right valve, ×2.3, length 17 mm, height 10 mm, LACMIP hypotype 7535, CSUN loc. 845. **119.** *Pitar* (*Lamelliconcha*) *joaquinensis* Vokes, 1939, left valve, ×2.2, length 16 mm, height 12 mm, LACMIP hypotype 7536, CSUN loc. 237. **120–121.** *Callista* (*Costacallista*) *hornii vokesi* new subspecies. All parts left valve, ×3, length 11 mm, height 9 mm, UCMP holotype 11667, UCMP loc. 672. **120.** Interior. **122.** *Callista* (*Macrocallista*) *domenginica* Vokes, 1939, left valve, ×1.3, length 25 mm, height 20 mm, LACMIP hypotype 7537, CSUN loc. 237. **123.** *Callocardia* (*Nitidavenus*) *tejonensis* (Waring, 1914), left valve, ×1.5, length 20 m, height 20 mm, LACMIP hypotype 7538, CSUN loc. 231. **124.** *Corbula* (*Caryocorbula*) *dickersoni* Weaver and Palmer, 1922, left valve, ×2.8, length 11.5 mm, height 7 mm, LACMIP hypotype 7539, CSUN loc. 807. **125.** *Corbula* (*Caryocorbula*) *parilis* Gabb, 1864, right valve, ×4.3, length 8 mm, height 6 mm, LACMIP hypotype 7540, CSUN loc. 237. **126.** *Corbula* (*Varicorbula*) *capayana* Vokes, 1939, right valve, ×7.3, length 4 mm, height 3 mm, LACMIP hypotype 7541, CSUN loc. 845. **127.** *Teredo*? sp., in petrified wood, ×1.2, length 48 mm, LACMIP hypotype 7542, CSUN loc. 362. **128.** *Pholadomya* (*Bucardiomya*) *givensi* Zinsmeister, 1978, internal mold, right valve, ×1.1, length 30 mm, height 18 mm, LACMIP hypotype 7543, CSUN loc. 816. **Figs. 129–130.** Ophiuroid and an echinoid. **129.** Unidentifiable ophiuroid, aboral view. ×2, greatest diameter 27 mm, LACMIP hypotype 7544, CSUN loc. 230. **130.** *Schizaster* cf. *S. lecontei* Merriam, 1899, internal mold, dorsal view, ×2, greatest diameter 18 mm, LACMIP hypotype 7545, CSUN loc. 843.

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 827.

Remarks. Three fragmentary specimens were found at locality 827. Two are internal molds. The third specimen (Fig. 115) has an anterior umbonal furrow set at an angle of 120° to the dorsal margin.

Previously, this species had not been reported with certainty as ranging into the "Capay Stage." Givens (1974:table 1) reported this species to range into the "Capay Stage," but his determination was based on a tentative occurrence.

Superfamily Tellinacea

Family Tellinidae Blainville, 1814

Subfamily Tellininae Blainville, 1814

Genus *Tellina* Linné, 1758

Type Species. By subsequent designation (Children, 1823), *Tellina radiata* Linné, 1758.

Subgenus *Macaliopsis* Cossmann, 1886

Type Species. By subsequent designation (Dall, 1900), *Tellina barrandei* Deshayes, 1857.

Tellina (*Macaliopsis*) new species? aff. *T.* (*M.*) *rosa* (Hanna, 1927)

Figure 116

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 845.

Remarks. A single specimen was found. It is a partial internal mold of a left valve, but shell is present along the anterior end. The specimen is similar to *Tellina* (*Macaliopsis*) *rosa* (Hanna, 1927:292, pl. 41, figs. 2–5, 8; Squires, 1984: 50, fig 12e) from "Domengine"-age strata, San Diego through Simi Valley, southern California. The Whitaker Peak specimen, however, has more closely spaced commarginal ribs and a slightly more pronounced depression from the beak to the posterior ventral margin. It may represent a new species.

The Whitaker Peak specimen also resembles *Tellina* (*Macaliopsis*) *biangularis* Deshayes (1824:82, pl. 12, figs. 1, 2; Cossmann and Pissarro, 1904–1906:pl. 6, fig. 35-28) from lower and middle Eocene strata, Paris Basin, France. The California specimen, however, has fewer and more widely spaced commarginal ribs and a stronger posterior umbonal fold.

The geologic range of *Macaliopsis* is Paleocene–Miocene according to Keen (1969) and Eocene according to Afshar (1969). Prior to this present report, it has only been found in Europe and eastern Central America (Keen, 1969).

Macaliopsis was considered to be a subgenus of *Arcopagia* by Afshar (1969), but *Arcopagia* is diagnosed as having an obsolete posterior fold. The presence of a strong posterior umbonal fold on the Whitaker Peak specimen supports the interpretation of Keen (1969) that *Macaliopsis* belongs in *Tellina*.

Family Psammobiidae Fleming, 1828

Subfamily Psammobiinae Fleming, 1828

Genus *Gari* Schumacher, 1817

Type Species. Pending decision by the ICZN, *Gari vulgaris* Schumacher, 1817 [=*Solen amethystus* Wood, 1818].

Gari texta Gabb, 1864

Figure 117

?*Gari texta* Gabb, 1864:155, pl. 22, fig. 130.
"*Gari*" *texta* Gabb. Stewart, 1930:283, pl. 7, fig. 12.
Gari texta Gabb. Vokes, 1939:93, pl. 15, fig. 1.

Primary Type Material. ANSP holotype 4471, Tejon Formation s.l., near Martinez, California.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley, southern California through central California and San Francisco regions.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 232.

Remarks. Only a single, large specimen (length 55 mm) was found. It is mostly an internal mold of a left valve. This species is characterized by fairly prominent commarginal ribbing with radial ribbing in the interspaces. On the Whitaker Peak specimen, the commarginal ribbing is preserved well, but the radial ribbing is only faintly preserved in the posterior ventral area.

Gari new species? aff. *G. eoundulata* Vokes, 1939

Figure 118

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 845.

Remarks. Three small specimens were found, and they are internal molds of single valves. They are similar to *G. eoundulata* Vokes (1939:93–94, pl. 14, figs. 23, 24) from "Capay Stage" and "Domengine Stage" strata, Fresno County, central California, but the Whitaker Peak specimens lack umbonal grooves in the posterior and anterior regions. The Whitaker Peak specimens may represent a new species.

Superfamily Veneracea

Family Veneridae Rafinesque, 1815

Subfamily Pitarinae Stewart, 1930

Genus *Pitar* Römer, 1857

Type Species. By monotypy, *Venus tumens* Gmelin, 1791.

Subgenus *Lamelliconcha* Dall, 1902

Type Species. By original designation, *Cytherea concinna* J. Sowerby, 1835.

Pitar (*Lamelliconcha*) *joaquinensis* Vokes, 1939

Figure 119

Metetrix hornii Gabb. Arnold, 1910:pl. 3, fig. 9. [Misidentification.]

Pitar (*Lamelliconcha*) *joaquinensis* Vokes, 1939:85–86, pl. 13, figs. 9–12. Givens, 1974:54, pl. 3, fig. 7. Squires, 1984: 51, fig. 12k.

Pitar? *joaquinensis* Vokes. Stewart, 1946:pl. 12, fig. 12.

Pitar joaquinensis Vokes. Givens and Kennedy, 1979: table 1.

Primary Type Material. UCMP holotype 15674, Domengine Formation, UCMP locality A-1027; UCMP paratype 15675, Domengine? Formation, UCMP locality 4175; UCMP paratype 15676, Domengine Formation, UCMP locality A-1027; UCMP paratype 15677, Avenal Formation, UCMP locality A-1280.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley, southern California through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 359. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN localities 363, 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. At locality 237, 25 specimens were found. At each of the other localities, about 17 specimens were found. Only single valves were found at all localities, and preservation is good.

Pitar (*L.*) *joaquinensis* is characterized by its ovate shape and moderately broad, flat commarginal ribs with linear interspaces. *Pitar* (*L.*) *joaquinensis* resembles *Callista* (*Macrocallista*) *domenginica* Vokes, but in *P.* (*L.*) *joaquinensis* the dorsal edges of the commarginal ribs are not steeper than the ventral edges, the ribs are not tilted toward the ventral margin, and the interspaces are linear impressions rather than V-shaped grooves. As noted by Vokes (1939), *P.* (*L.*) *joaquinensis* can be subovate to trigonal. Most of the Whitaker Peak specimens are subovate, but a few at locality 237 are trigonal in shape.

Previously, this species had not been reported as ranging into the "Capay Stage."

Genus *Callista* Poli, 1791

Type Species. By subsequent designation (Meek, 1876), *Venus chione* Linné, 1758.

Subgenus *Costacallista* Palmer, 1927

Type Species. By original designation, *Venus erycina* Linné, 1758.

Callista (*Costacallista*) *hornii vokesi* new subspecies

Figures 120, 121

Meretrix hornii Gabb. Dickerson, 1916:444, pl. 38, figs. 1a–b.

Pitar (*Lamelliconcha*) *hornii* new subspecies Vokes, 1939: 86–87, pl. 13, fig. 6.

Diagnosis. Generic assignment based on ovate shape, inequilateral valves, prosogyrate, well-developed anterior lateral, fairly long and narrow posterior cardinal. Subgeneric assignment based on strongly developed commarginal sculpture. Specific assignment based on numerous thin, vertical-sided commarginal ribs separated by flat-bottomed interspaces. Subspecific assignment based on flat-bottomed interspaces two to three times as wide as the thin commarginal ribs.

Callista (*Costacallista*) *hornii vokesi* new subspecies differs from typical *Callista* (*Costacallista*) *hornii* (Gabb, 1864:164, pl. 23, fig. 144; 1869:185, pl. 30, fig. 78; also see Givens, 1974:55 for synonymy) from upper middle through upper Eocene strata ("Transition" through "Tejon" "stages"), western and central Transverse Ranges, southern California (Givens, 1974), in the following features: less sharply rounded anteriorly and more broadly rounded posteriorly (Vokes, 1939). In addition, the interspaces between the ribs are wider than in the typical form. Useful comments and illustrations of *C.* (*C.*) *hornii* can be found in Stewart (1930:242–244, pl. 12, fig. 8; pl. 17, fig. 7) and Givens (1974:55, pl. 3, fig. 6).

Description. Shell small, inequilateral, subtrigonal, gently rounded anteriorly and broadly rounded posteriorly. Beak prominent, prosogyrate, and anterior to the midline of valve. Lunule small, flat, bounded by an incised line. Anteriormost half of the posterior dorsal margin with a prominent cord. Shell surface sculptured by strongly developed, thin, vertical-sided commarginal ribs, separated by flat-bottomed interspaces two to three times as wide as ribs.

Anterior cardinal thin and joined dorsally to the stout and triangular-shaped middle cardinal, posterior cardinal fairly long and narrow and about half the length of the nymph plate. Anterior lateral tooth well developed. Posterior lateral tooth very feeble. Valve margins internally smooth. Holotype length (complete) 11 mm, height (complete) 9 mm.

Primary Type Material. UCMP holotype 11667, UCMP paratype 15878, Domengine Formation, UCMP locality 672.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley, southern California through Coalinga area, central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 358, 359. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828.

Remarks. Three specimens were found at each of the localities. Only single valves were found, and preservation is fair to good.

Anderson and Hanna (1925:158) first recognized that Dickerson's (1916) "*Meretrix hornii* Gabb" is different from typical *Callista* (*Costacallista*) *hornii* (Gabb). Vokes (1939) also recognized the difference and proposed a new subspecies. He did not, however, name the subspecies. *Callista* (*Costacallista*) *hornii vokesi* new subspecies, therefore, is now erected. Dickerson's (1916) specimen (UCMP 15878) is chosen as the holotype (Figs. 120, 121), and Vokes' specimen (UCMP 11667) is chosen as the paratype. Vokes (1939) assigned the subspecies to *Pitar* (*Lamelliconcha*) although

Stewart (1930:242) had assigned the species to *Macrocallista* (*Costacallista*). The assignment to *Costacallista,* which is a subgenus of *Callista* in Keen (1969), seems justified at this time based on the nature of the strong sculpture although, admittedly, the preservable differences between *Pitar* (*Lamelliconcha*) and *Callista* (*Costacallista*) are subtle.

Previously, this subspecies had not been reported as ranging into the "Capay Stage."

Etymology. The subspecies is named for H.E. Vokes, in recognition of his many valuable contributions on Tertiary molluscs.

Subgenus *Macrocallista* Meek, 1876

Type Species. By original designation, *Venus gigantea* Gmelin, 1791 [=*Venus nimbosa* Lightfoot, 1786].

Callista (*Macrocallista*) *domenginica* Vokes, 1939

Figure 122

Meretrix uvasana "Conrad." Arnold, 1910:pl. 3, fig. 13. Arnold and Anderson, 1910:70, pl. 25, fig. 13. [Misidentification, *fide* Keen and Bentson, 1944:67.]

Macrocallista (*Costacallista*) *domenginica* Vokes, 1939:81, pl. 12, figs. 1–8.

Callista (*Microcallista*) *domenginica* (Vokes). Squires, 1977: table 1.

Primary Type Material. UCMP holotype 15654, Domengine Formation, UCMP locality 3315; UCMP paratype 15655, Domengine Formation, UCMP locality 3958; UCMP paratype 15656, Avenal Formation, UCMP locality A-975; UCMP paratype 15657, Domengine Formation, UCMP locality A-1220; UCMP paratypes 15658 and 15659, Domengine Formation, UCMP locality 3315.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Whitaker Peak area, southern California through central California.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 237.

Remarks. Seven single valves, ranging in height from 12 to 23 mm, were found. Preservation is good. This species is characterized by its ovate shape and moderately broad, flat-topped commarginal ribs that become more irregularly spaced with growth. The ribs are slightly tilted toward the ventral margin, and the dorsal sides of these ridges are steeper than the ventral sides.

Previously, this species had not been found south of the Coalinga, central California area.

Genus *Callocardia* A. Adams, 1864

Type Species. By monotypy, *Callocardia guttata* A. Adams, 1864.

Subgenus *Nitidavenus* Vokes, 1939

Type Species. By original designation, *Cytherea nitida* Deshayes, 1858.

Callocardia (*Nitidavenus*) *tejonensis* (Waring, 1914)

Figure 123

Isocardia tejonensis Waring, 1914:784–785; 1917:93, pl. 15, fig. 14.

cf. "*Isocardia tejonensis*" Waring. Turner, 1938:58, pl. 11, figs. 1–4.

Nitidavenus tejonensis (Waring). Vokes, 1939:83–84, pl. 12, figs. 11, 13–16.

Callocardia (*Nitidavenus*) *tejonensis* (Waring). Squires, 1984: 51, fig. 12h.

Primary Type Material. SU holotype 189, SU paratypes 5188–5190, Llajas Formation, SU locality 2696.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley, southern California through southwestern Oregon.

Local Occurrence. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN locality 231.

Remarks. Only a single specimen was found, but it is articulated and well preserved. This species is characterized by inflated, markedly prosogyrous beaks and a lunule bounded by an incised line. In addition, the commarginal ribbing becomes very fine on the beaks.

Order Myoida

Superfamily Myacea

Suborder Myina

Family Corbulidae Lamarck, 1818

Subfamily Corbulinae Lamarck, 1818

Genus *Corbula* Bruguière, 1797

Type Species. By subsequent designation (Schmidt, 1818), *Corbula sulcata* Lamarck, 1801.

Subgenus *Caryocorbula* Gardner, 1926

Type Species. By original designation, *Corbula alabamiensis* Lea, 1833.

Corbula (*Caryocorbula*) *dickersoni* Weaver and Palmer, 1922

Figure 124

Corbula dickersoni Weaver and Palmer, 1922:24–25, pl. 9, figs. 9–10. Clark, 1938:700, pl. 1, fig. 17. Weaver, 1943: 257–258, pl. 61, figs. 13, 16–17, 20. Deméré, Sundberg, and Schram, 1979:pl. 2, fig. 11.

Corbula (*Caryocorbula*) *dickersoni* Weaver and Palmer. Vokes, 1939:98, pl. 16, figs. 1, 5, 9. Givens, 1974:57, pl. 4, fig. 7. Squires, 1984:53, fig. 12m.

Primary Type Material. CAS holotype 7452, CAS paratypes 7452A–B, Cowlitz Formation, UW locality 329.

Molluscan Stage Range. "Capay" through "Tejon."

Geographic Distribution. San Diego, California through southwestern Washington.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 359?, 360, 361, 364, 807, 845.

Remarks. One to three specimens were found at each locality. Only single valves were found, and preservation is good.

The presence of *Corbula* (*Caryocorbula*) *dickersoni* in the *turritella uvasana infera* fauna of the Whitaker Peak section extends the molluscan stage range of this species into the "Capay Stage" proper. Previously, the lower range limit had been known to be uppermost "Capay" (Squires, 1984).

Corbula (*Caryocorbula*) *parilis* Gabb, 1864

Figure 125

Corbula parilis Gabb, 1864:150, pl. 29, figs. 239–239a. Arnold, 1910:106, pl. 2, fig. 2. Dickerson, 1915:84, pl. 4, fig. 8; 1916:pl. 40, fig. 10. Hanna, 1927:295, pl. 43, figs. 7–11, 13. Stewart, 1930:288–289, pl. 3, fig. 5; 1946:pl. 11, figs. 9–10. Turner, 1938:65–66, pl. 8, figs. 11–14. Weaver, 1943: 256, pl. 59, fig. 16. Givens and Kennedy, 1979:tables 1, 3–4.

Corbula (*Caryocorbula*) *parilis* Gabb. Vokes, 1939:99, pl. 16, figs. 2–3, 6–7, 10. Givens, 1974:57, pl. 4, fig. 9. Squires, 1977:table 1.

Primary Type Material. UCMP holotype 33151, Eocene strata, Martinez, California (see Turner, 1938:65–66).

Molluscan Stage Range. "Capay" through "Transition."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. *Turritella uvasana applinae* fauna, Juncal Formation: CSUN locality 828. *Turritella uvasana applinae* fauna, Matilija Sandstone?: CSUN localities 232, 237, 808.

Remarks. One or two specimens were found at each locality, except at locality 237 where 19 specimens were found. Most of the specimens are right valves. Preservation is best at locality 237 where specimens faintly show the presence of the characteristic caneellate sculpture.

Subgenus *Varicorbula* Grant and Gale, 1931

Type Species. By original designation, *Tellina gibba* Olivi, 1792.

Corbula (*Varicorbula*) *capayana* Vokes, 1939

Figure 126

Corbula (*Varicorbula*) *capayana* Vokes, 1939:99–100, pl. 16, figs. 13–15.

Primary Type Material. UCMP holotype 15733, "Arroyo Hondo Formation," UCMP locality 1817.

Molluscan Stage Range. "Meganos"? through "Capay."

Geographic Distribution. Whitaker Peak area, southern California, through central California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 361, 362, 844, 845.

Remarks. Twenty-four specimens were found at locality 361, eight at 844, and two at each of the other localities. The specimens are mostly right valves, and preservation is fair. Height range is from 3 through 6.5 mm.

This small, distinctive species is characterized by its strong, broad umbonal ridge that extends to the posterior ventral margin, as well as by the numerous well-developed commarginal ribs that do not cross the umbonal ridge. The posterior area, however, is marked by strong irregular lines of growth.

See "Remarks" for *Turritella andersoni* in this present report for a discussion of the age of the type locality (UCMP locality 1817) of this species.

Previously, this species had not been found anywhere else except in the Coalinga area, central California.

Suborder Pholadina

Superfamily Pholadacea

Family Teredinidae Rafinesque, 1815

Subfamily Teredininae Rafinesque, 1815

Genus *Teredo* Linné, 1758

Type Species. By subsequent designation (ICZN, 1926, opin. 94), *Teredo navalis* Linné, 1758.

Teredo? sp.

Figure 127

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN localities 362, 825, 829.

Remarks. *Teredo*? sp. occurs in the Whitaker Peak area as calcareous-lined burrows in small pieces of petrified wood. Generic determination is uncertain, and it is very possible that future workers will assign these fossils to another genus.

Subclass Anomalodesmata

Order Pholadomyoida

Superfamily Pholadomyacea

Family Pholadomyidae Gray, 1847a

Genus *Pholadomya* G.B. Sowerby, 1823

Type Species. By subsequent designation (Gray, 1847a), *Pholadomya candida* G.B. Sowerby, 1823.

Subgenus *Bucardiomya* Rollier *in* Cossmann, 1912

Type Species. By subsequent designation (Rollier *in* Cossmann, 1912), *Pholadomya bucardium* Agassiz.

Pholadomya (*Bucardiomya*) *givensi* Zinsmeister, 1978

Figure 128

Pholadomya (*Pholadomya*) sp. Givens, 1974:58, pl. 4, fig. 5.
Pholadomya (*Bucardiomya*) *givensi* Zinsmeister, 1978:235, fig. 1.

Primary Type Material. UCR holotype 4662/110, Juncal Formation, UCR locality 4662.

Molluscan Stage Range. "Capay."

Geographic Distribution. Whitaker Peak and Pine Mountain areas, southern California.

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 816.

Remarks. This species is rare in the Whitaker Peak section. Only two specimens were found, and both are internal molds of articulated individuals.

Phylum Echinodermata

Subphylum Asterozoa

Class Stelleroidea

Subclass Ophiuroidea

Order Indeterminate

Ophiuroid

Figure 129

Local Occurrence. Only a single specimen was found. It is an aboral surface. Four of the five rays are present, and the fifth one is mostly missing. Details of the central disc have been obliterated due to poor preservation, hence, identification could only be made to the subclass level.

Subphylum Echinozoa

Class Echinoidea

Subclass Euechinoidea

Superorder Atelostomata

Order Spatangoida

Suborder Hemiasterina

Family Schizasteridae Lambert, 1902

Genus *Schizaster* Agassiz, 1836

Type Species. By subsequent designation (ICZN, 1954, opin. 209), *Schizaster studeri* Agassiz, 1836.

Schizaster cf. *S. lecontei* Merriam, 1899

Figure 130

Local Occurrence. *Turritella uvasana infera* fauna, Juncal Formation: CSUN locality 843.

Remarks. Two specimens were found, and they are internal molds. In the best preserved specimen (Fig. 130), the anterior half of the test has been compressed into the middle portion of the test. The very short bivium of the apical system, nevertheless, appears to be in its original position and is centrally located. The specimens resemble *S. lecontei* Merriam (1899: 164–165, pl. 21, figs. 1, 1a; Clark and Twitchell, 1915:151–152, pl. 69, figs. 3a, b; Kew, 1920:151–152, pl. 41, figs. 3a–d; Grant and Hertlein, 1938:120–121, pl. 15, fig. 10; Weaver, 1953:28) from Paleocene strata, northern California, but poor preservation prevents a positive specific identification.

LOCALITIES

CSUN macrofossil and microfossil localities collected by the author in the course of this study are listed first. CSUN macrofossil type localities mentioned in the text but collected during previous studies outside of the study area are listed next. Localities of other institutions mentioned in this report follow in alphabetical order.

All CSUN study area localities are in the Juncal Formation or the Matilija Sandstone?, Whitaker Peak area, Los Angeles and Ventura counties, southern California. Unless otherwise noted, they are in the United States Geological Survey 7.5-minute topographic quadrangle of Whitaker Peak, California, 1958. Abbreviations used are United States Geological Survey (USGS), feet (ft.), meters (m), township (T), range (R), north (N), south (S), east (E), and west (W). Distances are given in both English and metric units, but map contour elevations are given in English units only. Some localities are located in sections in which the north–south section lines do not parallel true north. In order to plot these localities, as described for each one in the following locality descriptions, measure the east or west direction along the appropriate east–west section line, then measure the north or south direction on a line perpendicular to the appropriate east–west section line.

Unless otherwise indicated, the CSUN localities are in transition-zone deposits. The general location, relative stratigraphic position, informal biostratigraphic zone, and provincial molluscan "stage" of each CSUN locality are shown in Figures 132 through 135.

CSUN MACROFOSSIL LOCALITIES

28. At elevation of 1460 ft. on east side of a side canyon to Piru Creek, 475 ft. (145 m) north and 675 ft. (206 m) west of SE corner of section 10, T 5 N, R 18 W. [Tidal-flat deposits.]

81. At elevation of 1580 ft. on east side of same side canyon as for locality 28, 125 ft. (38 m) south and 280 ft. (85 m) west of SE corner of section 19, T 5 N, R 18 W. [Tidal-flat deposits.]

214. At elevation of 1360 ft. on west side of a side canyon to Canton Canyon, 225 ft. (69 m) north and 2700 ft. (823 m) east of SE corner of section 10, T 5 N, R 18 W. [Tidal-flat deposits.]

216. At elevation of 1820 ft. at top of small cliff, 1350 ft. (411 m) south and 800 ft. (244 m) east of NE corner of section 10, T 5 N, R 18 W. [Tidal-flat deposits.]

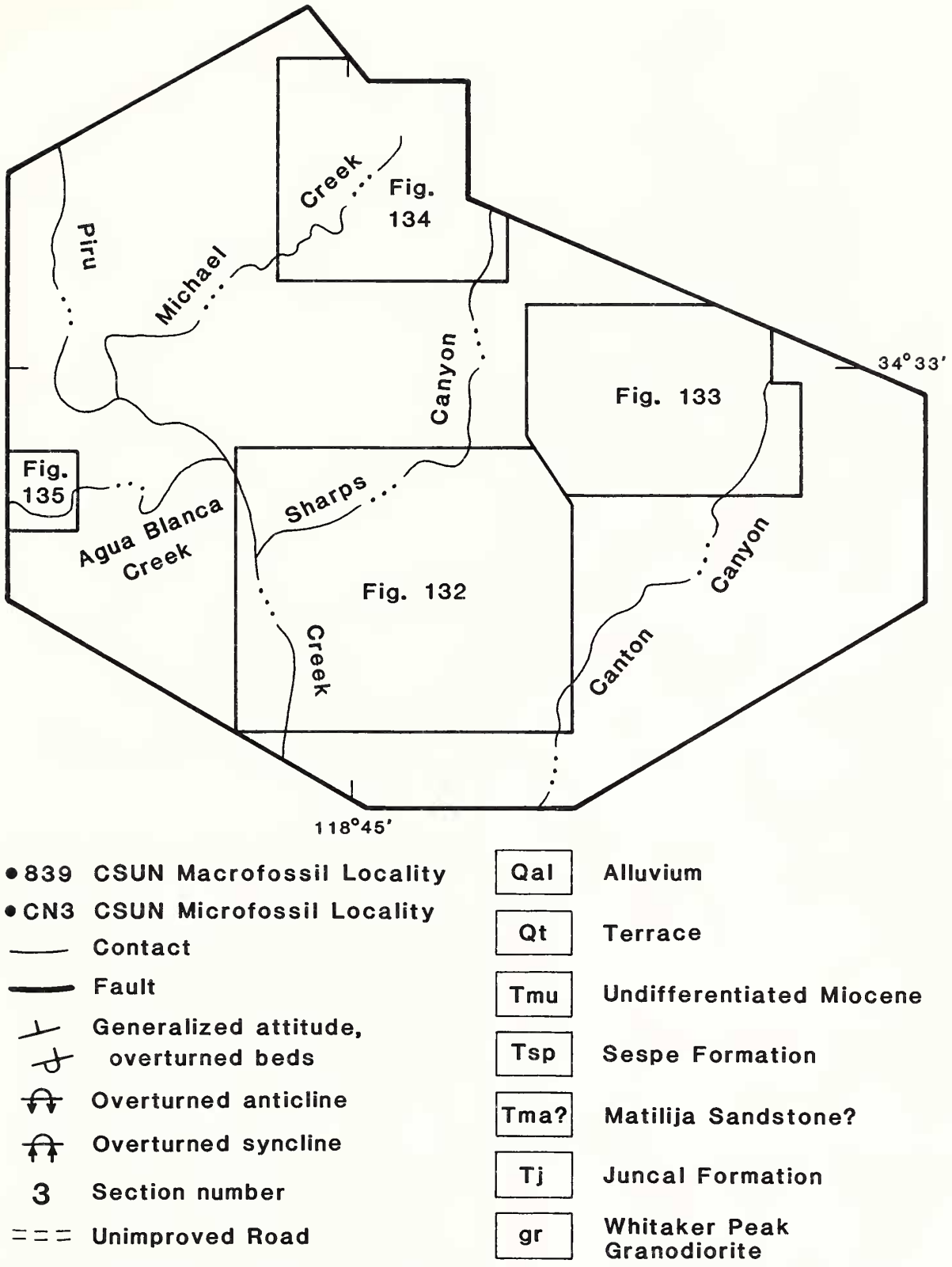
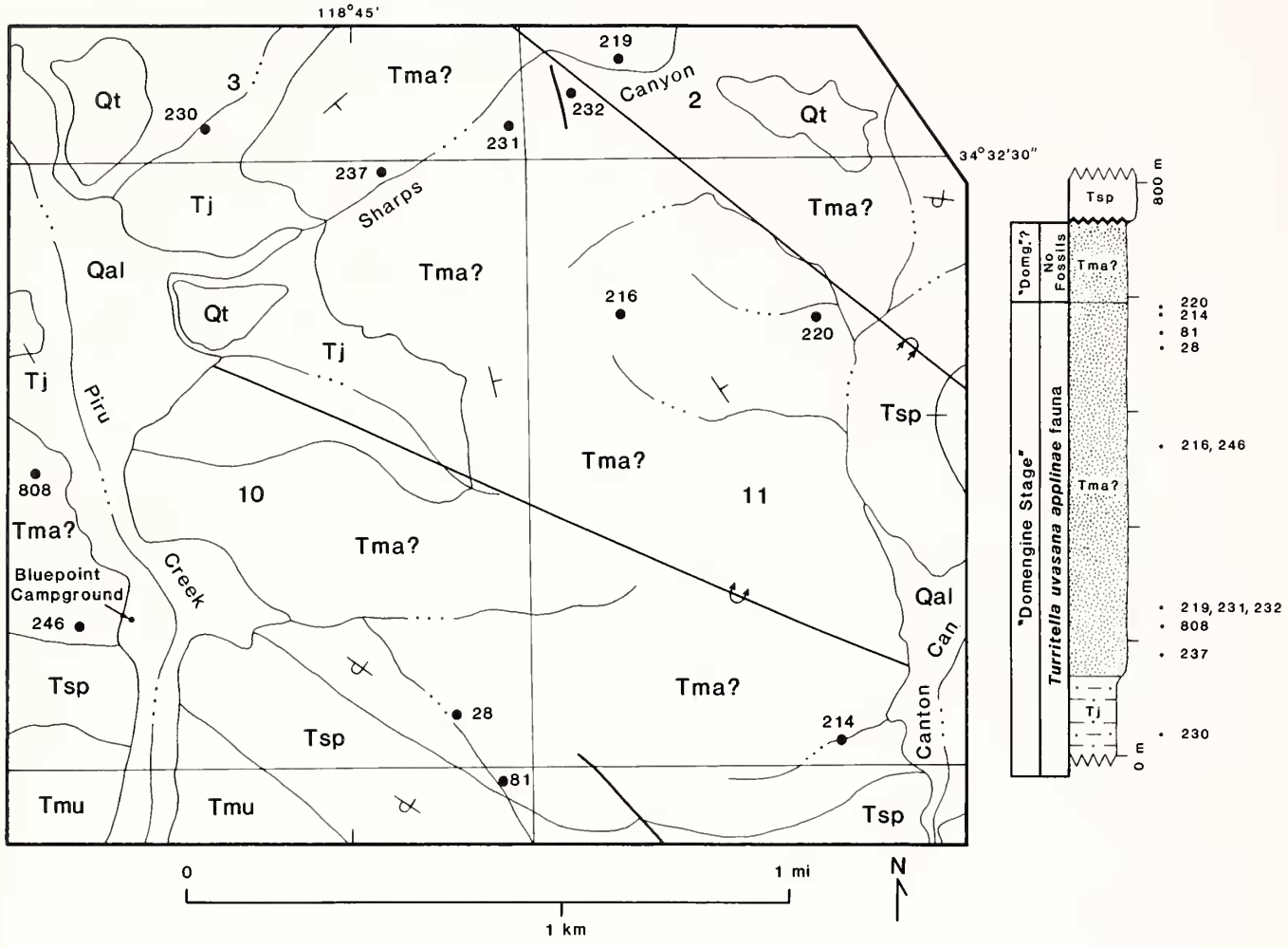


Figure 131. Index map to the Whitaker Peak area showing locations of areas used as fossil locality maps in Figures 132–135. An explanation of symbols used on the locality maps is also given.



BASE MAP FROM COBBLESTONE MTN. (1958) AND WHITAKER PEAK (1958), CA., 7.5-MINUTE QUADRANGLES

Figure 132. Geologic map showing CSUN macrofossil localities, Juncal Formation and Matilija Sandstone?, Piru Creek to Canton Canyon area. Accompanying columnar section shows stratigraphic position of the macrofossil localities. See Figure 131 for explanation of symbols.

219. At elevation of 1720 ft. on north side of Sharps Canyon, 800 ft. (244 m) east of SW corner of section 2, T 5 N, R 18 W, and 850 ft. (259 m) north along a line perpendicular to the southern east–west section line. Same bed as that at localities 231 and 232. [Delta-front deposits.]

220. At elevation of 1460 ft. on west side of a side canyon to Canton Canyon, 1375 ft. (419 m) south and 2500 ft. (762 m) east of NE corner of section 10, T 5 N, R 18 W.

230. At elevation of 1275 ft. in streambed of side canyon to Piru Creek, 300 ft. (91 m) north and 2800 ft. (853 m) west of NE corner of section 10, T 5 N, R 18 W, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

231. At elevation of 1670 ft. on east side of Sharps Canyon, 300 ft. (91 m) north and 125 ft. (38 m) west of NE corner of section 10, T 5 N, R 18 W. Same bed as that at localities 219 and 232. [Delta-front deposits.]

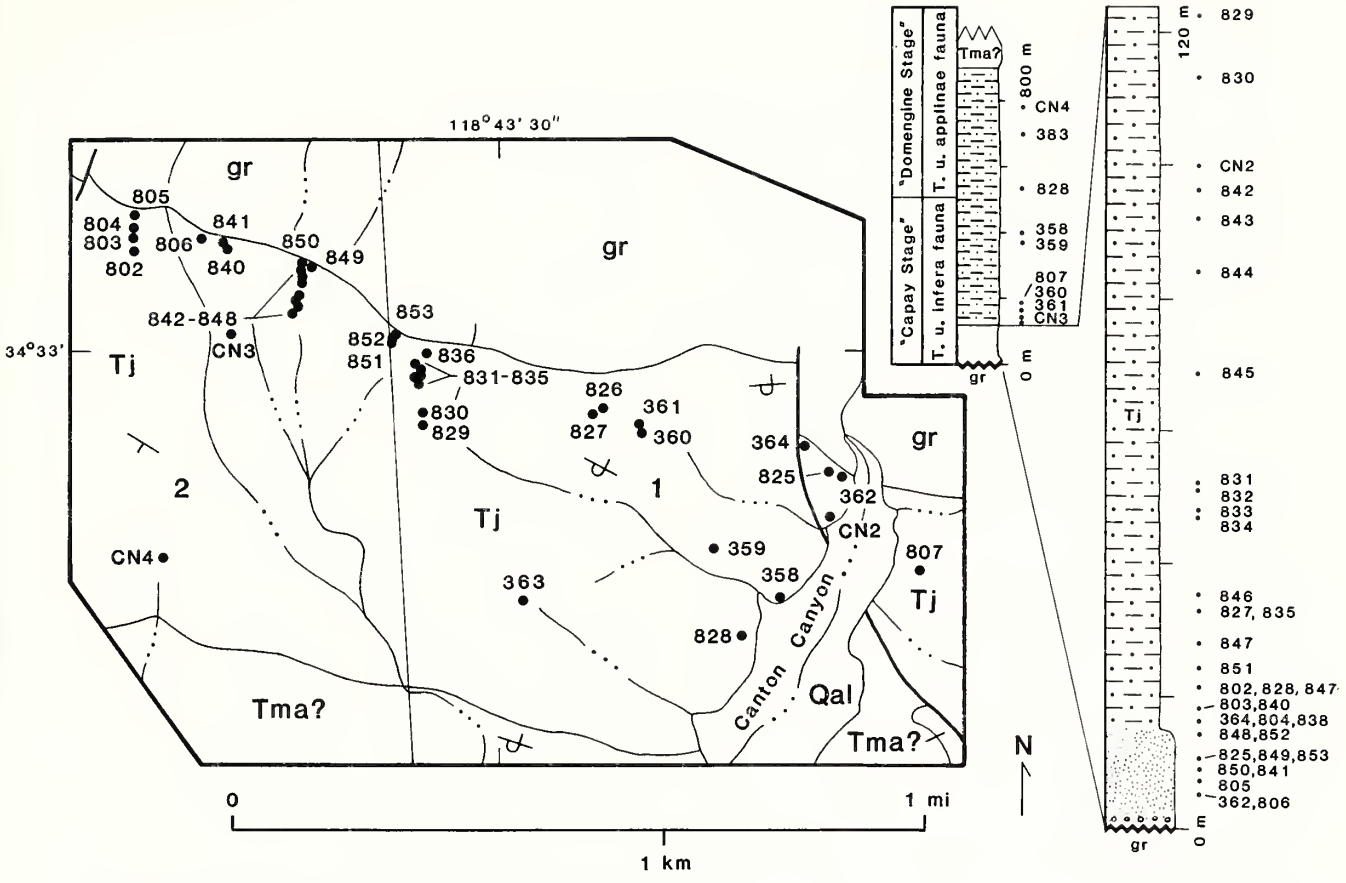
232. At elevation of 1840 ft. on east side of Sharps Canyon, 400 ft. (122 m) east of SW corner of section 2, T 5 N, R 18 W, and 600 ft. (183 m) north along a line perpendicular to the southern east–west section line. Same bed as that at localities 219 and 231. [Delta-front deposits.]

237. At elevation of 1390 ft. on west side of Sharps Canyon, 100 ft. (30 m) south and 1275 ft. (389 m) west of NE corner of section 10, T 5 N, R 18 W. [Delta-front deposits.]

246. At elevation of 1375 ft. on west side of Piru Creek, just west of Bluepoint Campground, 1275 ft. (389 m) north and 1300 ft. (396 m) east of SW corner of section 10, T 5 N, R 18 W, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958. [Tidal-flat deposits.]

358. At elevation of 1580 ft. on west side of Canton Canyon, 2775 ft. (846 m) east of SW corner of section 1, T 5 N, R 18 W, and 1150 ft. (350 m) north along a line perpendicular to the southern east–west section line. Locality is equivalent to UCLA locality 7210.

359. At elevation of 1760 ft. on north side of side canyon to Canton Canyon, 2275 ft. (693 m) east of SW corner of



BASE MAP FROM WHITAKER PEAK (1958), CA., 7.5-MINUTE QUADRANGLE

Figure 133. Geologic map showing CSUN macrofossil and microfossil localities, Juncal Formation, Canton Canyon area. Accompanying columnar section shows stratigraphic position of the fossil localities. See Figure 131 for explanation of symbols.

section 1, T 5 N, R 18 W, and 1575 ft. (480 m) north along a line perpendicular to the southern east–west section line.

360. At elevation of 2200 ft. on west side of ridge, 1750 ft. (533 m) east of SW corner of section 1, T 5 N, R 18 W, and 2460 ft. (750 m) north along a line perpendicular to the southern east–west section line.

361. At elevation of 2240 ft. on west side of ridge, 1730 ft. (527 m) east of SW corner of section 1, T 5 N, R 18 W, and 2525 ft. (770 m) north along a line perpendicular to the southern east–west section line.

362. At elevation of 1690 ft. on west side of Canton Canyon, 3250 ft. (991 m) east of SW corner of section 1, T 5 N, R 18 W, and 2110 ft. (643 m) north along a line perpendieular to the southern east–west section line. [Nearshore-marine deposits.]

363. At elevation of 2060 ft. on east side of ridge, 830 ft. (253 m) east of SW corner of section 1, T 5 N, R 18 W, and 1200 ft. (366 m) north along a line perpendicular to the southern east–west section line.

364. At elevation of 1910 ft. on ridge, 2950 ft. (899 m) east of SW corner of section 1, T 5 N, R 18 W, and 2350 ft. (716 m) north along a line perpendicular to the southern east–west section line.

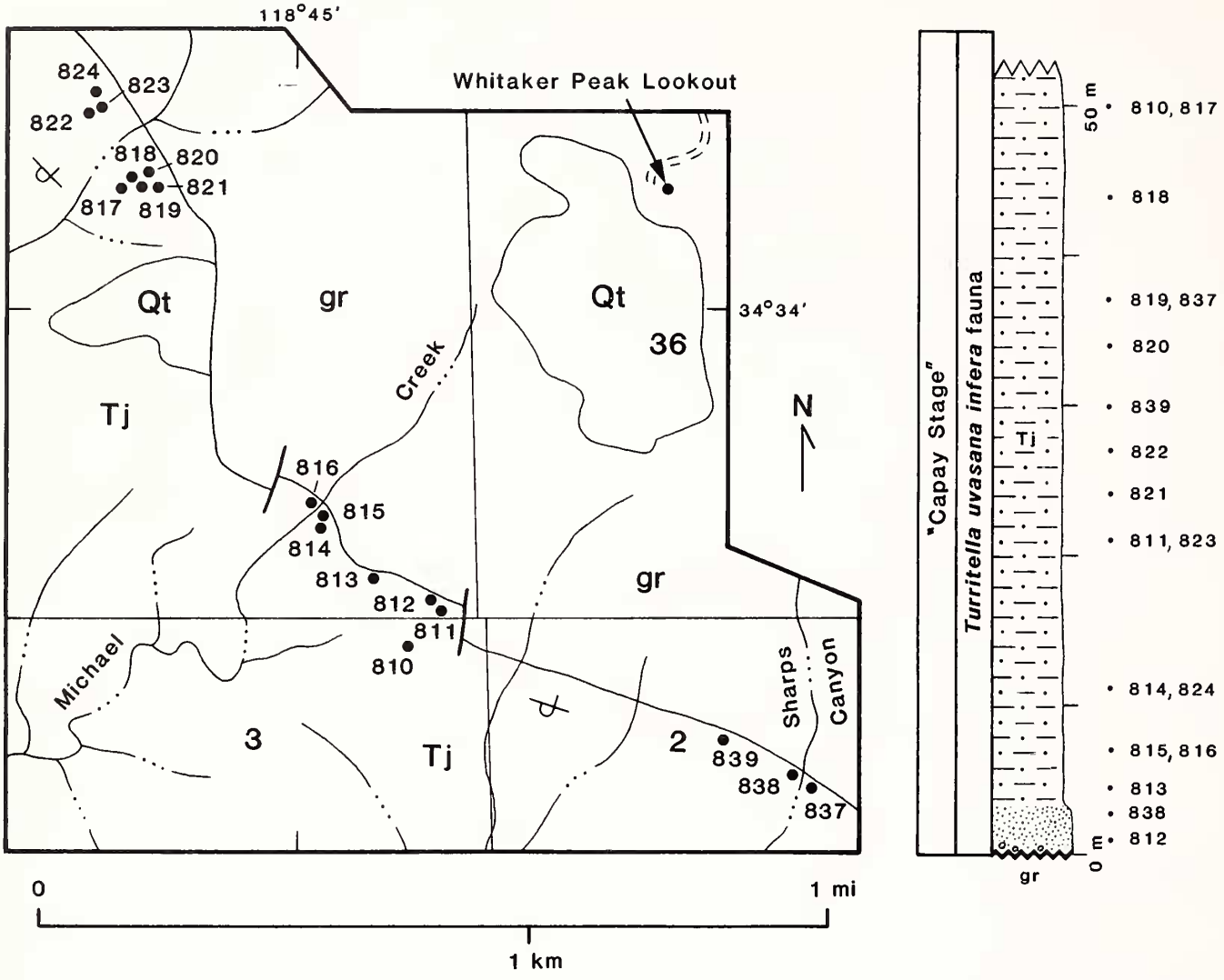
802. At elevation of 2690 ft. on ridge, 2090 ft. (637 m) west of SE corner of section 2, T 5 N, R 18 W, and 3910 ft. (1192 m) north along a line perpendicular to the southern east–west section line.

803. At elevation of 2700 ft. on ridge, 2100 ft. (640 m) west of SE corner of section 2, T 5 N, R 18 W, and 4010 ft. (1222 m) north along a line perpendicular to the southern east–west section line.

804. At elevation of 2710 ft. on ridge, 2100 ft. (640 m) west of SE corner of section 2, T 5 N, R 18 W, and 4075 ft. (1242 m) north along a line perpendicular to the southern east–west section line.

805. At elevation of 2730 ft. on ridge, 2075 ft. (632 m) west of SE corner of section 2, T 5 N, R 18 W, and 4200 ft. (1280 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]

806. At elevation of 2540 ft. on west side of ridge, 1580 ft. (482 m) west of SE corner of section 2, T 5 N, R 18 W, and 3950 ft. (1204 m) north along a line perpendicular to



BASE MAP FROM COBBLESTONE MTN. (1958) AND WHITAKER PEAK (1958), CA., 7.5-MINUTE QUADRANGLES

Figure 134. Geologic map showing CSUN macrofossil localities, Juncal Formation, Sharps Canyon to northwest of Michael Creek area. Accompanying columnar section shows stratigraphic position of the macrofossil localities. See Figure 131 for explanation of symbols.

the southern east–west section line. [Nearshore-marine deposits.]

807. At elevation of 1720 ft. on east side of Canton Canyon, 1450 ft. (442 m) west of SE corner of section 1, T 5 N, R 18 W, and 1450 ft. (442 m) north along a line perpendicular to the southern east–west section line.

808. At elevation of 1275 ft. on west side of Piru Creek, 2600 ft. (792 m) north and 4300 ft. (1311 m) west of SE corner of section 10, T 5 N, R 18 W, USGS Cobblestone Mountain, 7.5-minute, quadrangle, 1958. [Delta-front deposits.]

809. At elevation of 1275 ft. at base of cliff on north side of Agua Blanca Creek, 25 ft. (8 m) south and 675 ft. (206 m) east of NW corner of section 9, T 5 N, R 18 W, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958. [Tidal-flat deposits, lower part].

810. At elevation of 2910 ft. on a ridge, 500 ft. (152 m) west of NE corner of section 3, T 5 N, R 18 W, and 200 ft. (61 m) south along a line perpendicular to the northern east–west section line.

811. At elevation of 2980 ft. on east side of ridge, 260 ft. (79 m) west of NE corner of section 3, T 6 N, R 18 W, and 25 ft. (8 m) north along a line perpendicular to the northern east–west section line.

812. At elevation of 3000 ft. on west side of ridge, 325 ft. (99 m) west of NE corner of section 3, T 6 N, R 18 W, and 115 ft. (35 m) north along a line perpendicular to the northern east–west section line. [Nearshore-marine deposits.]

813. At elevation of 2910 ft. on east side of ridge, 750 ft. (229 m) west of corner of section 3, T 6 N, R 18 W, and 250 ft. (76 m) north along a line perpendicular to the northern east–west section line.

814. At elevation of 2720 ft. on a small ridge, 1075 ft. (328 m) west of NE corner of section 3, T 6 N, R 18 W, and 630 ft. (192 m) north along a line perpendicular to the northern east–west section line.

815. At elevation of 2760 ft. on a small ridge, 1050 ft. (320 m) west of NE corner of section 3, T 6 N, R 18 W, and 700 ft. (213 m) north along a line perpendicular to the northern east–west section line.

816. At elevation of 2760 ft. on west side of stream bank, 1125 ft. (343 m) west of NE corner of section 3, T 6 N, R 18 W, and 750 ft. (229 m) north along a line perpendicular to the northern east–west section line.

817. At elevation of 2450 ft. on side of hill, 2400 ft. (732 m) west of NE corner of section 3, T 5 N, R 18 W, and 2850 ft. (869 m) north along a line perpendicular to the northern east–west section line, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

818. At elevation of 2500 ft. on side of hill, 2350 ft. (716 m) west of NE corner of seetion 3, T 5 N, R 18 W, and 2900 ft. (884 m) north along a line perpendicular to the northern east–west section line, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

819. At elevation of 2550 ft. on side of hill, 2300 ft. (701 m) west of NE corner of seetion 3, T 5 N, R 18 W, and 2860 ft. (872 m) north along a line perpendicular to the northern east–west section line, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

820. At elevation of 2575 ft. on side of hill, 2250 ft. (686 m) west of NE corner of section 3, T 5 N, R 18 W, and 2925 ft. (892 m) north along a line perpendicular to the northern east–west section line, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

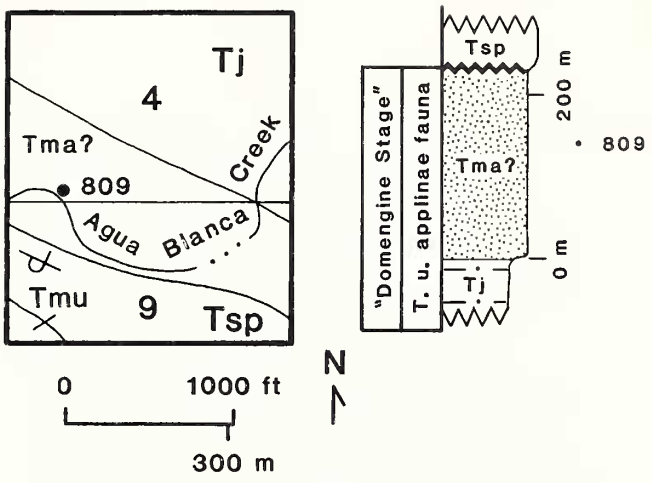
821. At elevation of 2625 ft. on side of hill, 2170 ft. (661 m) west of NE corner of section 3, T 5 N, R 18 W, and 2835 ft. (864 m) north along a line perpendicular to the northern east–west section line, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

822. At elevation of 2650 ft. on west side of canyon, 2290 ft. (698 m) west of NE corner of section 3, T 5 N, R 18 W, and 3350 ft. (1020 m) north along a line perpendicular to the northern east–west section line, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

823. At elevation of 2610 ft. on west side of canyon, 2575 ft. (785 m) west of NE corner of section 3, T 5 N, R 18 W, and 3400 ft. (1036 m) north along a line perpendicular to the northern east–west section line, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

824. At elevation of 2650 ft. on west side of canyon, 2600 ft. (792 m) west of NE corner of section 3, T 5 N, R 18 W, and 3450 ft. (1052 m) north along a line perpendicular to the northern east–west section line, USGS Cobblestone Mountain, 7.5-minute quadrangle, 1958.

825. At elevation of 1760 ft. on west side of Canton Canyon, 3180 ft. (937 m) east of SW corner of section 1, T 5 N, R 18 W, and 2150 ft. (632 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]



BASE MAP FROM COBBLESTONE MTN. (1958), CA., 7.5-MINUTE QUADRANGLE

Figure 135. Geologic map showing CSUN macrofossil locality 809, Matilija Sandstone?, Agua Blanca Creek area. Accompanying columnar section shows stratigraphic position of the macrofossil locality. See Figure 131 for explanation of symbols.

826. At elevation of 2310 ft. on west side of ridge, 1460 ft. (445 m) east of SW corner of section 1, T 5 N, R 18 W, and 2650 ft. (808 m) north along a line perpendicular to the southern east–west section line.

827. At elevation of 2300 ft. on west side of ridge, 1390 ft. (424 m) east of SW corner of section 1, T 5 N, R 18 W, and 2625 ft. (800 m) north along a line perpendicular to the southern east–west section line.

828. At elevation of 1660 ft. on west side of Canton Canyon, 2475 ft. (754 m) east of SW corner of section 1, T 5 N, R 18 W, and 910 ft. (277 m) north along a line perpendicular to the southern east–west section line.

829. At elevation of 2340 ft. on ridge top, 100 ft. (30 m) east of SW corner of section 1, T 5 N, T 18 W, and 2550 ft. (777 m) north along a line perpendicular to the southern east–west section line.

830. At elevation of 2350 ft. on ridge top, 100 ft. (30 m) east of SW corner of section 1, T 5 N, R 18 W, and 2650 ft. (808 m) north along a line perpendicular to the southern east–west section line.

831. At elevation of 2450 ft. on ridge top, 60 ft. (18 m) east of SW corner of section 1, T 5 N, R 18 W, and 2875 ft. (876 m) north along a line perpendicular to the southern east–west section line.

832. At elevation of 2460 ft. on ridge top, 50 ft. (15 m) east of SW corner of section 1, T 5 N, R 18 W, and 2900 ft. (884 m) north along a line perpendicular to the southern east–west section line.

833. At elevation of 2480 ft. on ridge top, 100 ft. (30 m)

east of SW corner of section 1, T 5 N, R 18 W, and 2925 ft. (892 m) north along a line perpendicular to the southern east–west section line.

834. At elevation of 2490 ft. on ridge, 100 ft. (30 m) east of SW corner of section 1, T 5 N, R 18 W, and 2975 ft. (907 m) north along a line perpendicular to the southern east–west section line.

835. At elevation of 2485 ft. on ridge, 50 ft. (15 m) east of SW corner of section 1, T 5 N, R 18 W, and 3000 ft. (914 m) north along a line perpendicular to the southern east–west section line.

836. At elevation of 2530 ft. on ridge, 125 ft. (38 m) east of SW corner of section 1, T 5 N, R 18 W, and 3075 ft. (937 m) north along a line perpendicular to the southern east–west section line.

837. At elevation of 2500 ft. on east side of Sharps Canyon, 3400 ft. (1036 m) west of SE corner of section 2, T 5 N, R 18 W, and 5750 ft. (1753 m) north along a line perpendicular to the southern east–west section line.

838. At elevation of 2500 ft. on west side of Sharps Canyon, 3500 ft. (1067 m) west of SE corner of section 2, T 5 N, R 18 W, and 5850 ft. (1783 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]

839. At elevation of 2840 ft. on west side of Sharps Canyon, 3975 ft. (1212 m) west of SE corner of section 2, T 5 N, R 18 W, and 6060 ft. (1844 m) north along a line perpendicular to the southern east–west section line.

840. At elevation of 2560 ft. on ridge, 1380 ft. (421 m) west of SE corner of section 2, T 5 N, R 18 W, and 3910 ft. (1192 m) north along a line perpendicular to the southern east–west section line.

841. At elevation of 2600 ft. on ridge, 1410 ft. (430 m) west of SE corner of section 2, T 5 N, R 18 W, and 3970 ft. (1210 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]

842. At elevation of 2180 ft. on a small cliff on east side of stream bank, 900 ft. (274 m) west of SE corner of section 2, T 5 N, R 18 W, and 3400 ft. (1036 m) north along a line perpendicular to the southern east–west section line.

843. At elevation of 2220 ft. on a low ridge, 850 ft. (259 m) west of SE corner of section 2, T 5 N, R 18 W, and 3475 ft. (1059 m) north along a line perpendicular to the southern east–west section line.

844. At elevation of 2240 ft. on a low ridge, 850 ft. (259 m) west of SE corner of on 2, T 5 N, R 18 W, and 3500 ft. (1067 m) north along a line perpendicular to the southern east–west section line.

845. At elevation of 2260 ft. on a low ridge, 840 ft. (2560 m) west of SE corner of section 2, T 5 N, R 18 W, and 3550 ft. (1082 m) north along a line perpendicular to the southern east–west section line.

846. At elevation of 2300 ft. on a low ridge, 830 ft. (253 m) west of SE corner of section 2, T 5 N, R 18 W, and 3650 ft. (1113 m) north along a line perpendicular to the southern east–west section line.

847. At elevation of 2330 ft. on a low ridge, 830 ft. (253 m) west of SE corner of section 2, T 5 N, R 18 W, and 3700 ft. (1128 m) north along a line perpendicular to the southern east–west section line.

848. At elevation of 2340 ft. on a low ridge, 830 ft. (253 m) west of SE corner of section 2, T 5 N, R 18 W, and 3750 ft. (1143 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]

849. At elevation of 2350 ft. on a low ridge, 800 ft. (244 m) west of SE corner of section 2, T 5 N, R 18 W, and 3770 ft. (1149 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]

850. At elevation of 2360 ft. at base of small cliff, 830 ft. (253 m) west of SE corner of section 2, T 5 N, R 18 W, and 3800 ft. (1158 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]

851. At elevation of 2480 ft. on ridge, 150 ft. (46 m) west of SE corner of section 2, T 5 N, R 18 W, and 3200 ft. (975 m) north along a line perpendicular to the southern east–west section line.

852. At elevation of 2510 ft. on ridge, 125 ft. (38 m) west of SE corner of section 2, T 5 N, R 18 W, and 3225 ft. (983 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]

853. At elevation of 2530 ft. at base of cliff on a ridge, 115 ft. (35 m) west of SE corner of section 2, T 5 N, R 18 W, and 3275 ft. (998 m) north along a line perpendicular to the southern east–west section line. [Nearshore-marine deposits.]

CSUN MICROFOSSIL LOCALITIES

CN1. Same as CSUN macrofossil locality 837.

CN2. At elevation of 1620 ft. on west side of Canton Canyon, 3180 ft. (969 m) east of SW corner of section 1, T 5 N, R 18 W, and 1800 ft. (549 m) north along a line perpendicular to the southern east–west section line.

CN3. At elevation of 2270 ft. on a low ridge, 1375 ft. (419 m) west of SE corner of section 2, T 5 N, R 18 W, and 3250 ft. (991 m) north along a line perpendicular to the southern east–west section line.

CN4. At elevation of 2320 ft. on west side of ridge at head of a small canyon, 1850 ft. (564 m) west of SE corner of section 2, T 5 N, R 18 W, and 1570 ft. (479 m) north along a line perpendicular to the southern east–west section line.

CSUN LOCALITIES OUTSIDE OF STUDY AREA

374. At elevation of 1700 ft. on a small cliff on south side of a side canyon to Las Llajas Canyon, 1950 ft. (594 m) north and 1825 ft. (556 m) east of SE corner of section 29, T 3 N, R 17 W, 7.5-minute topographic quadrangle of Santa Susana, California, 1951 (photorevised, 1969), Ventura County.

662. At elevation of 2190 ft. along crest of small hill, 450 ft. (137 m) south and 100 ft. (31 m) west of the NE corner of section 25, T 6 S, R 12 E, 7.5-minute topographic quadrangle of Canyon Spring NW, California, 1963, Riverside County. Locality is equivalent to UCLA locality 3779.

CAS LOCALITIES

25. On east bank of Little River at its confluence with Umpqua River, near center of section 19, T 26 S, R 3 W. Roseburg quadrangle, Douglas County, Oregon.

244. In east bank of Live Oak Creek, 0.75 mi. (1.2 km) from mouth, 3 mi. (4.8 km) due east of mouth of Grapevine Canyon, Tejon quadrangle, Kern County, California.

393. Devil Canyon, SE ¼ of the NW ¼ of section 26, T 3 N, R 17 W, Santa Susana quadrangle, Los Angeles County, California.

711. East side of Grapevine Creek near point where it enters valley floor, Tejon quadrangle, Kern County, California.

792. West side of Tecuya Creek, about 1 mi. (1.6 km) south of where stream flows out on valley floor, Tejon quadrangle, Kern County, California.

SU LOCALITY

2696. Chivo Canyon, 5 km N20°E of Bench Mark 961 at Santa Susana, Santa Susana quadrangle, Ventura County, California.

UCMP LOCALITIES

337. About 5 km south of Martinez, on the east side of the road to Walnut Creek, Concord quadrangle, Contra Costa County, California.

672. South portion of crest of Parson's Peak, SE ¼ of the NW ¼ of section 24, T 18 S, R 14 E, Coalinga quadrangle, Fresno County, California.

1817. Opposite the place where Urruttia Canyon enters Salt Creek, 100 ft. (30 m) up fourth small draw from west end of Ridge, SE ¼ of the NW ¼ of section 15, T 18 S, R 14 E, Coalinga quadrangle (1912), Fresno County, California.

1853. Marysville Buttes, N ½ of section 28, T 16 N, R 1 E, Marysville Buttes quadrangle, Sutter County, California.

1855. Marysville Buttes, 0.5 mi. (0.8 km) SW of UCMP locality 1853, Marysville Buttes quadrangle, Sutter County, California.

2226. Longitude 117°14′W, latitude 33°50′N, SE of Soledad Mountain, north of Ladrillo Station, Southern Pacific Railroad, Rose Canyon, La Jolla quadrangle, San Diego County, California.

3152. Deer Valley, NW ¼ of section 20, T 1 N, R 2 E, Mt. Diablo quadrangle, Contra Costa County, California.

3310. Exact location unknown. Probably Simi Hills, Santa Susana quadrangle, California.

3315. Immediately south of Domengine Creek, Coalinga quadrangle, Fresno County, California.

3958. No locality data available.

3986. At 20 ft. (6 m) above high-tide level, 1 mi. (1.6 km) north of Scripps Institute, La Jolla quadrangle, San Diego County, California.

3990. On east side of canyon in bottom of Rose Creek, 0.3 mi. (0.5 km) east of "t" of "Soledad Mountain," La Jolla quadrangle, San Diego County, California.

3993. In bottom of Rose Creek where creek makes a strong bend to west, 0.2 mi. (0.3 km) south of Bench Mark 176, 2 mi. (3.2 km) east of La Jolla, La Jolla quadrangle, San Diego County, California.

4052. Top of hill 2223 directly north of divide between Holser and Martinez Chiquite Canyon, Santa Susana quadrangle, California.

4169. About 500 ft. (152 m) east of ranch house in Big Tar Canyon on east line of section 18, near point where road crosses creek. Garza Peak quadrangle, Kings County, California.

4170. On west side of Big Tar Canyon, where it crosses the Eocene section, Garza Peak quadrangle, Kings County, California.

4175. No locality data available. Probably Domengine Ranch area, north of Coalinga, Domengine Ranch quadrangle, Fresno County, California.

5062. In sea cliff south of mouth of Soledad Valley, due west of midpoint between "P" and "u" of "Pueblo," La Jolla quadrangle, San Diego County, California.

7000. Exact location unknown. Las Llajas Canyon, in first canyon on north side of road, Santa Susana quadrangle, California.

7004. At elevation of 1700 ft. on a small cliff on south side of a side canyon to Las Llajas Canyon, 1950 ft. (594 m) north and 1825 ft. (556 m) east of SE corner of section 29, T 3 N, R 17 W, Santa Susana quadrangle, Ventura County, California. Locality is equivalent to CSUN locality 374.

7195. In the creek bed about 60 ft. (18 m) north of the second falls or 300 ft. (91 m) north of the mouth of the first small draw which enters Las Llajas Canyon west of the point where the "Meganos" Conglomerate crosses the road, Santa Susana quadrangle, Ventura County, California.

A-667. Section along north bank of North Umpqua River from the bend 0.25 mi. (0.4 km) north of Glide to Bradley Creek, a distance of approximately 0.5 mi. (0.8 km). Douglas County, Oregon.

A-819. Lowest reef bed on side of hill just east of and above first saddle south of Big Tar Canyon, Garza Peak quadrangle, Kings County, California.

A-975. In draw across ridge to south of Big Tar Canyon, Reef Ridge, T 23 S, R 17 E, Cholame quadrangle, Kings County, California.

A-994. Second draw past Las Llajas Canyon at second small falls up draw approximately 300 ft. (91 m), Santa Susana quadrangle, Ventura County, California.

A-1003. Exact location unknown. Pine Canyon, Mount Diablo, Contra Costa County, California.

A-1027. Valdes Ranch, on branch of Silver Creek, Vallecitos, center of east part of SW ¼ of section 4, T 16 S, R 12 E. Approximately where 120°40′ parallel crosses most northerly intermittent stream indicated on section 4, Panoche quadrangle, Fresno County, California.

A-1173. 0.75 mi. (1.2 km) west of Cleveland, Oregon in ravine 900 ft. (274 m) south of road, west of Roseburg, Oregon.

A-1219. Base of Domengine Formation on west side, near top, of long ridge extending NW of 2126-ft. hill on line between sections 9 and 16, T 19 S, R 15 E, Domengine Ranch quadrangle, Fresno County, California.

A-1220. On long ridge NW of hill 2126, 1/16 in. on map north of line between sections 9 and 16, T 19 S, R 15 E, Coalinga quadrangle, Fresno County, California.

A-1233. No locality data available.

A-1280. Near center of north edge of section 20, on hill immediately south of point where the Big Tar–McLure Valley road crosses saddle at head of stream running into McLure Valley, 45 ft. (14 m) below uppermost fossiliferous layer, Garza Peak quadrangle, Kings County, California.

UCLA LOCALITY

4713. At about elevation of 1925 ft. on west side of Canton Canyon, about 3900 ft. S36°W from hill 3105 which is in the NW ¼ of section 6, T 5 N, R 17 W. Whitaker Peak quadrangle, Los Angeles County, California.

UCR LOCALITIES

4662. In bed of Hot Spring Canyon, 1900 ft. (579 m) north, 2050 ft. (625 m) west of SE corner of section 21, T 6 N, R 20 W, Topatopa Mountain quadrangle, Ventura County, California.

4847. At Ardath Road southbound on ramp to Interstate Freeway 5, 32,820 m north, 78,250 m east in zone 11 of the Universal Transverse Mercator grid system, La Jolla quadrangle, San Diego County, California.

USGS LOCALITIES

4617. On SW flank of Reef Ridge, north of McLure Valley, 2¼ mi. (3.6 km) SSE of El Cerrito oil well, section 27, T 23 S, R 17 E, Cholame quadrangle, Kings County, California.

4619. North of Coalinga, 15 mi. (24 km) SW of Domengine's Ranch, T 18 S, R 15 E, Coalinga quadrangle, Fresno County, California.

UW LOCALITIES

329. On north bank of the Cowlitz River at bend 1.5 to 2.5 km east of Vader, section 28, T 1 N, R 2 W, Lewis County, Washington.

358. Joice Station, ¼ mi. (0.4 km) east of Tongue Point Railroad, Port Crescent, section 22, T 31 N, R 8 W, Clallam County, Washington.

ACKNOWLEDGMENTS

The following California State University, Northridge, geology students kindly assisted in collecting macrofossil specimens: R. Demetrion, T. Garvey, L. Groves, S. Grupp, E. Leisker, Jr., A. Marinello, B. Menzie, and D. Yamashiro.

D.R. Lindberg, University of California, Berkeley; M.A. Kooser, University of California, Riverside; P.U. Rodda, California Academy of Sciences, San Francisco; and L.R. Saul and E.C. Wilson, Los Angeles County Museum, provided access to collections and kindly provided the loan of specimens. J. Le Renard, a private collector from Plaisir, France, also loaned specimens from his collection of Paris Basin Eocene molluscs. F.E. Wells, Western Australian Museum, Perth, generously arranged for modern specimens of *Campanile* to be sent to the Los Angeles County Museum.

L.R. Saul identified the *Fimbria* specimen and gave numerous valuable insights and comments regarding molluscan identification and taxonomy. L.R. Saul also provided many papers dealing with the synonymy of *Velates perversus*. J.W. Durham, University of California, Berkeley, identified the coral *Astrocoenia* specimens. P.U. Rodda identified the *Athleta* specimens. C.R. Givens (Nicholls State University) provided many critical comments on molluscan taxonomy.

D.R. Lindberg, J.H. McLean (Los Angeles County Museum), E.J. Moore (United States Geological Survey, Menlo Park), and T. Susuki (University of California, Los Angeles) provided valuable comments on molluscan identification. A.G. Fischer (University of Southern California) gave helpful comments on the age of the Ranikot beds, Pakistan. R.H. Miller (San Diego State University) helped in getting an unpublished reference dealing with *Fimbria*.

M.V. Filewicz, Unocal Corporation, graciously processed nine rock samples and identified the calcareous nannofossils. M.L. Cotton Thornton, Unocal Corporation, kindly processed splits of the same nine rock samples and identified the planktonic and benthic foraminifera.

M. Schutt, Oviatt Library, California State University, Northridge, arranged for numerous interlibrary loans of references. R. Takagi, University of California, Berkeley, aided in the use of the Berkeley macrofossil collections.

G.L. Kennedy (Los Angeles County Museum) gave helpful editorial comments. C.R. Givens and W.J. Zinsmeister (Purdue University) critically reviewed the manuscript, and their thoughtful comments provided appreciated suggestions for improvement.

LITERATURE CITED

Abbott, R.T. 1954. American seashells. Van Nostrand Reinhold, New York. 541 pp.

———. 1968. The helmet shells of the world (Cassidae), Part 1. Indo-Pacific Mollusca 2(9):15–200.

Abbott, R.T., and S.P. Dance. 1982. Compendium of sea shells. E.P. Dutton, New York. 411 pp.

Adams, A. 1850. *In* Sowerby, G.B., Thesaurus conchyliorum, monographs of genera of shells, vol. 2. London.

———. 1864. On the species of *Neara* found in the seas of Japan. Annals and Magazine of Natural History, ser. 3, 13:206–209.

Adams, H., and A. Adams. 1853–1858. The genera of Recent Mollusca; arranged according to their organization. 3 vols. John Van Voorst, London. 1145 pp.

Adegoke, O.S. 1972. Tethyan affinities of West African Paleogene Mollusca. International Geological Congress, 24th session, section 7, Paleontology, pp. 441–449.

———. 1977. Stratigraphy and paleontology of the Ewekoro Formation (Paleocene) of southwestern Nigeria. Bulletins of American Paleontology 71(295):1–379.

Afshar, F. 1969. Taxonomic revision of the superspecific groups of the Cretaceous and Cenozoic Tellinidae. Geological Society of America, Memoir 119. 215 pp.

Agassiz, L.J.R. 1836. Mémoires de la Société Science Naturelle Neuchatel, vol. 1. Paris.

Aldrich, T.H. 1886. Preliminary report on the Tertiary fossils of Alabama and Mississippi. Geological Survey of Alabama, Bulletin 1(1):15–60.

———. 1911. New Eocene fossils from the southern Gulf States. Bulletins of American Paleontology 5(22). 24 pp.

Allen, J.A. 1958. On the basic form and adaptations to habitat in the Lucinacea (Eulamellibranchia). Royal Society of London, Philosophical Transactions, ser. B, 241: 421–484.

Anderson, F.M. 1928. Notes on lower Tertiary deposits of Colombia and their molluscan and foraminiferal fauna. California Academy of Sciences, Proceedings, ser. 4, 17: 1–29.

———. 1938. Lower Cretaceous deposits in California and Oregon. Geological Society of America, Special Paper 16:1–339.

Anderson, F.M., and G.D. Hanna. 1925. Fauna and stratigraphic relations of the Tejon Eocene at the type locality in Kern County, California. California Academy of Sciences, Occasional Papers 11:1–249.

———. 1928. *Solen novacularis,* a name for an Eocene fossil from California. The Nautilus 42(2):65–66.

Anderson, R.M. 1960. Geology of part of the lower Piru Creek area, Ventura and Los Angeles counties, California. University of California Los Angeles, Unpublished M.S. thesis. 96 pp.

Anderson, R., and R.W. Pack. 1915. Geology and oil resources of the west border of the San Joaquin Valley north of Coalinga, California. United States Geological Survey, Bulletin 603. 220 pp.

Archiac, A. d', and J. Haime. 1853–1854. Description des animaux fossiles du groupe nummulitique de l'Inde. 2 vols. Gide and J. Baudry, Paris. 373 pp.

Arnold, R. 1903. The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, California. California Academy of Sciences, Memoir 3:1–420.

———. 1907. New and characteristic speeies of fossil mollusks from the oil-bearing Tertiary formations of southern California. United States National Museum, Proceedings 32:525–546.

———. 1909. Environment of the Tertiary faunas of the Pacifie Coast of the United States. Journal of Geology 17:509–533.

———. 1910. Paleontology of the Coalinga district, Fresno and Kings counties, California. United States Geological Survey, Bulletin 396:1–173.

Arnold, R., and R.V.V. Anderson. 1910. Geology and oil resources of the Coalinga district, California. United States Geological Survey, Bulletin 398:1–354.

Arnold, R., and H. Hannibal. 1913. The marine Tertiary stratigraphy of the North Pacific coast of America. American Philosophical Society, Proceedings 52:559–605.

Axelrod, D.I. 1984. An interpretation of Cretaceous and Tertiary biota in polar regions. Palaeogeography, Palaeoclimatology, Palaeoecology 45:105–147.

Bailey, T.L., and R.H. Jahns. 1954. Geology of the Transverse Ranges Province, southern California. Pages 83–106 *in* Jahns, R.H., ed., Geology of southern California. California Division of Mines and Geology, Bulletin 170, Chapter 2, no. 6.

Bellardi, L. 1872–1889. I molluschi dei terreni Terziari del Piemonte e della Liguria. Musei de Zoologia ed Anatomia Comparata della R. Universita di Torino, Bollettino pts. 1–6.

Berggren, W.A., and Hollister, C.D. 1974. Paleogeography, paleobiogeography and the history of circulation in the Atlantic Ocean. Pages 126–186 *in* Hay, W.W., ed., Studies in paleo-oceanography. Society of Economic Paleontologists and Mineralogists, Special Publication 20.

Berggren, W.A. et al. 1985. Cenozoic geochronology. Geological Society of America, Bulletin 96(11):1407–1418.

Bernard, F.R. 1976. Living Chamidae of the eastern Pacific (Bivalvia: treterodonta). Natural History Museum of Los Angeles County, Contributions in Science 278:1–43.

Berthiaume, S.A. 1938. Orbitoids from the Crescent Formation (Eocene) of Washington. Journal of Paleontology 12:494–497.

Beu, A.G. 1986. A classification and catalogue of living world Ranellidae (=Cymatiidae) and Bursidae. Conchologists of America Bulletin 13:55–66.

Blainville, H.M.D. de. 1804–1845. Dictionnaire universel des sciences naturelles. 61 vols. Paris.

Blondeau, A., and E.E. Brabb. 1983. Large foraminifers of Eocene age from the Coast Ranges of California. Pages 41–48 *in* Brabb, E.E., ed., Studies in Tertiary stratigraphy of the California Coast Ranges. United States Geological Survey, Professional Paper 1213.

Blow, W.H. 1969. Late middle Eocene to Recent planktonic foraminiferal biostratigraphy. Pages 199–422 *in* Bronnimann, R., and Renz, H.H., eds., Proceedings of the first international conference on planktonic microfossils, Geneva, 1967. Vol. 1. E.J. Brill, Leiden.

Bretsky, S.S. 1976. Evolution and classification of Cenozoic North American and European Lucinidae (Mollusca, Bivalvia). Palaeontographica Americana 8(50):219–337.

British Museum (Natural History). 1975. British Caenozoic fossils (Tertiary and Quaternary), 5th ed. British Museum (Natural History), Publication no. 540, London. 132 pp.

Brongniart, A. 1823. Mémoire sur les terrains de sédiments supérieurs calcaréo-trappéens de Vicentin. Paris.

Bruguière, J.G. 1789–1816. Encyclopédie méthodique ou par ordre et matières. Histoire naturelle des Vers, des Mollusques. 758 pp. Atlas, 488 pp.

Cernohorsky, W.O. 1970. Systematics of the families Mitridae and Volutomitridae (Mollusca: Gastropoda). Auckland Institute and Museum, Bulletin 8. 190 pp.

———. 1976. The Mitridae of the World. Part 1. The subfamily Mitrinae. Indo-Pacific Mollusca 3(17):273–528.

Chavan, A. 1969. Superfamily Lucinacea Fleming, 1828. Part N, Mollusca 6, Bivalvia, vol. 2, pp. 491–518 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.

Chédeville, P.-J. 1901. Liste générale et synonymique des fossiles Tertiaires du bassin de Paris. Bulletin de la Société d'étude des Sciences Naturelles d'Elbeuf, sér. 4, 19: 111–176.

———. 1902. Liste générale et synonymique des fossiles Tertiaires du bassin de Paris. Bulletin de la Société d'étude des Sciences Naturelles d'Elbeuf, sér. 4, 20:227–294.

———. 1904a. Description de fossiles nouveaux du bassin Tertiaire de Paris. Bulletin de la Société d'étude des Sciences Naturelles d'Elbeuf, sér. 4, 22:101–106.

———. 1904b. Liste générale et synonymique des fossiles Tertiaires du bassin de Paris. Bulletin de la Société d'étude des Sciences Naturelles d'Elbeuf, sér. 4, 22:375–438.

Chemnitz, J.H. 1780–1795. Neues systematisches conchylien Cabinet, vols. 4–11. Bauer and Raspe, Nürnberg.

Children, J.G. 1822–1824. Lamarck's genera of shells, translated from the French. Quarterly Journal of Science, vols. 14–16.

Clark, B.L. 1918. The San Lorenzo Series of middle California. University of California, Publications in Geological Sciences 11(2):45–234.

———. 1929. Stratigraphy and faunal horizons of the Coast Range of California. Privately published. 132 pp.

———. 1938. Fauna from the Markley Formation (upper Eocene) on Pleasant Creek, California. Geological Society of America, Bulletin 49(5):683–730.

———. 1943. Notes on California Tertiary correlation. California Division of Mines, Bulletin 118(pt. 2):187–191.

Clark, B.L., and J.W. Durham. 1946. Eocene faunas from the Department of Bolivar, Colombia. Geological Society of America, Memoir 16:1–126.

Clark, B.L., and D.K. Palmer. 1923. Revision of the *Rimella*-like gastropods from the West Coast of North America. University of California, Publieations in Geological Sciences 14(7):277–288.

Clark, B.L., and H.E. Vokes. 1936. Summary of marine Eocene sequences of western North America. Geological Society of America, Bulletin 47:851–878.

Clark, B.L., and A. O. Woodford. 1927. The geology and paleontology of the type section of the Meganos Formation (lower middle Eocene) of California. University of California, Publications in Geological Sciences 17(2): 63–142.

Clark, W.B., and M.W. Twitchell. 1915. The Mesozoic and Cenozoic Echinodermata of the United States. United States Geological Survey, Monograph 54. 341 pp.

Clements, T. 1937. Structure of the southeastern part of the Tejon quadrangle, California. American Association of Petroleum Geologists, Bulletin 21:212–232.

Cole, W.S. 1958. Names of and variations in certain American larger foraminifera, particularly the discocyclinids—No. 3. Bulletins of American Paleontology 38:411–429.

———. 1969. Names of and variation in Central American larger foraminifera, particularly the Eocene pseudophragminids—No. 4. Bulletins of American Paleontology 56(248):1–55.

Cole, W.S., and E. R. Applin. 1964. Problem of the geographic and stratigraphic distribution of American middle Eocene larger foraminifera. Bulletins of American Paleontology 47(212):1–48.

Conrad, T.A. 1832. Fossil shells of the Tertiary formations of North America. Vol. 1, no. 2. Privately published. 17 pp.

———. 1833. On some new fossil and Recent shells of the United States. American Journal of Science and Arts 23(2):339–346.

———. 1847. Observations on the Eocene formation, and descriptions of one hundred and five new species of that period, from the vicinity of Vicksburg, Mississippi, with an appendix. Academy of Natural Sciences of Philadelphia, Proceedings 3:280–299.

———. 1853. Synopsis of the genera *Cassidula,* Humph., and of a proposed new genus *Athleta.* Academy of Natural Sciences of Philadelphia, Proceedings 6:448–449.

———. 1855. Report on the fossil shells collected in California by W.P. Blake. Pages 5–20 *in* Preliminary geological report of W.P. Blake, United States 33rd Congress, 1st session, House Executive Document 129.

———. 1857. Descriptions of the fossil shells. Pages 317–329 *in* Williamson, R.S., Report of explorations in California for railroad routes, United States 33rd Congress, 2nd session, Senate Executive Document 78 and House Executive Document 91, vol. 5, pt. 2, appendix 2.

———. 1860. Description of new species of Cretaceous and Eocene fossils of Mississippi and Alabama. Academy of Natural Sciences of Philadelphia, Journal, 2nd series, 4(3):275–298.

———. 1865. Catalogue of the Eocene and Oligocene Testacea of the United States. American Journal of Conchology 1:1–35.

———. 1866. Check list of the invertebrate fossils of North America. Eocene and Oligocene. Smithsonian Miscellaneous Collections 7(200):1–41.

———. 1867. Descriptions of new genera and species of

Miocene shells, with notes on other fossil and Recent species. American Journal of Conchology 3:257–270.
Cooke, C.W. 1919. Tertiary mollusks from the Leeward Islands and Cuba. Carnegie Institute of Washington Publication 291:103–156.
———. 1946. *Velates vokesi*, new name for *Neritina? grandis* Cooke. Journal of Paleontology 20:295.
Cooper, J.G. 1894. Catalogue of Californian fossils, parts 2–5. California State Mining Bureau, Bulletin 4:5–65.
Cossmann, A.E.M. 1886. Catalogue illustré des coquilles fossiles de l'Eocène des environs de Paris. Société Royale Malacologique de Belgique 21:17–186.
———. 1888. Catalogue illustré des coquilles fossiles de l'Eocène des environs de Paris. Annales de la Société Royale Malacologique de Belgique 23:3–324.
———. 1889. Catalogue illustré des coquilles fossiles de l'Eocène des environs de Paris. Gastropodes. Annales de la Société Royale Malacologique de Belgique 24:3–381.
———. 1899. Essais de paléoconchologie comparée. Vol. 3. Privately published, Paris.
———. 1906. Essais de paléoconchologie comparée. Vol. 7. Privately published, Paris.
———. 1912. Sur l'évolution des Trigonies. Annales Paléontologie 7:59–84.
———. 1916. Essais de paléoconchologie comparée. Vol. 11. Privately published, Paris.
———. 1918. Essais de paléoconchologie comparée. Vol. 12. Privately published, Paris.
———. 1925. Essais de paléoconchologie comparée. Vol. 13. Privately published, Paris.
Cossmann, A.E.M., and G. Pissarro. 1904–1906. Iconographie completé des coquilles fossiles de l'Eocène des environs de Paris. Société Géologique de France. Vol. 1 (Pélécypodes). 45 pls. Paris.
———. 1909. The Mollusca of the Ranikot Series. Part 1. Cephalopoda and Gastropoda. Memoirs of the Geological Survey of India, Palaeontologia Indica, new ser., vol. 3, Memoir no. 1, 83 pp.
———. 1910–1913. Iconographie completé des coquilles fossiles de l'Eocène des environs de Paris. Société Géologique de France. Vol. 2 (Gastropodes, etc.). 65 pls. Paris.
Costa, E.M. da. 1778. Historia naturalis testaceorum Brittanniae. Private publication, London, 254 pp.
Cox, L.R. 1930. The fossil fauna of the Samana Range and some neighbouring areas. Part 8, The Mollusca of the Hangu shales. Memoirs of the Geological Survey of India, Palaeontologica Indica 15:129–222.
———. 1931. A contribution to the molluscan fauna of the Laki and basal Khirthar Groups of the Indian Eocene. Transactions of the Royal Society of Edinburgh 57(2): 25–92.
Cox, L.R., and L.G. Hertlein. 1969. Family Plicatulidae Watson, 1930. Part N, Mollusca 6, Bivalvia, vol. 1, pp. 377–380 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.
Cox, L.R. et al. 1969. Systematic descriptions. Part N, Mollusca 6, Bivalvia, vols. 1 and 2, pp. 225–952 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.
Crowell, J.C. 1954. Strike-slip displacement of the San Gabriel fault, southern California. Pages 49–52 *in* Jahns, R.H., ed., Geology of southern California. Chapter 4, Structural features. California Division of Mines, Bulletin 170.
Crowell, J.C., and T. Susuki. 1959. Eocene stratigraphy and paleontology, Orocopia Mountains, southeastern California. Geological Society of America, Bulletin 70:581–592.
Dall, W.H. 1890. Contributions to the Tertiary fauna of Florida with especial reference to the Miocene *Silex* beds of Tampa and the Pliocene beds of the Caloosahatchie River. Pt. I. Transactions of the Wagner Free Institute of Science of Philadelphia 3:1–200.
———. 1892. Contributions to the Tertiary fauna of Florida, . . . Pt. II. Transactions of the Wagner Free Institute of Science of Philadelphia 3:201–473.
———. 1900. Synopsis of the family Tellinidae and of the North American species. United States National Museum, Proceedings 23:285–326.
———. 1902. Illustrations and descriptions of new unfigured, or imperfectly known shells, chiefly American, in the United States National Museum. United States National Museum, Proceedings 24:499–566.
———. 1903. Synopsis of the Carditacea and of the American species. Academy of Natural Sciences of Philadelphia, Proceedings 54:695–716.
———. 1904. An historical and systematic review of the frog-shells of tritons. Smithsonian Miscellaneous Collections 47:114–144.
———. 1909. Contributions to the Tertiary paleontology of the Pacific Coast. I. The Miocene of Astoria and Coos Bay, Oregon. United States Geological Survey, Professional Paper 59:1–278.
———. 1915. A monograph of the molluscan fauna of the *Orthaulax pugnax* zone of the Oligocene of Tampa, Florida. United States National Museum, Bulletin 90. 173 pp.
Darragh, T.A. 1971. Revision of the Australian Tertiary Volutidae (Mollusca: Gasteropoda). 1. The subfamily Athletinae. Journal of the Malacological Society of Australia 2(2):163–185.
Davies, A.M. 1971. Tertiary faunas: Vol. 1. The composition of Tertiary faunas. American Elsevier Publishing Company, New York. 571 pp.
———. 1975. Tertiary faunas: Vol. 2. The sequence of Tertiary faunas. Revised and updated by F.E. Eames and R.J.G. Savage. George Allen and Unwin, London. 447 pp.
Dawson, M.K. 1978. The paleontology of the Cabrillo Formation. San Diego State University, Unpublished M.S. thesis. 96 pp.
Defrance, D.F. 1804–1845. Dictionnaire des sciences naturelles. Paris and Strasbourg. 61 vols.
Deméré, T.A., F.A. Sundberg, and F.R. Schram. 1979. Pa-

leoecology of a protected biotope from the Eocene Mission Valley Formation, San Diego County, California. Pages 97–102 *in* Abbott, P.L., ed., Eocene depositional systems, San Diego, California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Field Trip Guide, Geological Society of America Annual Meeting.

Deshayes, M.G.P. 1824–1837. Descriptions des coquilles fossiles des environs de Paris. 2 vols. Chez l'auteur et d'autres. Paris. 814 pp. Atlas, 101 pls.

———. 1856–1866. Description des animaux sans vertèbres découverts dans le bassin de Paris. 3 vols. J.-B. Baillière et fils, Paris. 2536 pp. Atlas (2 vols.), 107 pls.

Dibblee, T.W., Jr. 1966. Geology of the central Santa Ynez Mountains, Santa Barbara County, California. California Division of Mines and Geology, Bulletin 186. 99 pp.

———. 1982. Geology of the Santa Ynez-Topatopa Mountains, southern California. Pages 41–56 *in* Fife, D.L., and J.A. Minch, eds., Geology and mineral wealth of the California Transverse Ranges. South Coast Geological Society, Annual Symposium and Guidebook Number 10.

Dickerson, R.E. 1913. Fauna of the Eocene at Marysville Buttes, California. University of California, Publications in Geological Sciences 7(12):257–298.

———. 1914a. The Martinez Eocene and associated formations at Rock Creek on the western border of the Mohave Desert area. University of California, Publications in Geological Sciences 8(14):289–298.

———. 1914b. New molluscan species from the Martinez Eocene of southern California. University of California, Publications in Geological Sciences 8(15):299–304.

———. 1914c. The fauna of the *Siphonalia sutterensis* Zone in the Roseburg Quadrangle, Oregon. California Academy of Sciences, Proceedings, ser. 4, 4:113–128.

———. 1914d. Fauna of the Martinez Eocene of California. University of California, Publications in Geological Sciences 8(6):61–180.

———. 1915. Fauna of the type Tejon: its relation to the Cowlitz phase of the Tejon Group of Washington. California Academy of Sciences, Proceedings, ser. 4, 5(3): 33–98.

———. 1916. Stratigraphy and fauna of the Tejon Eocene of California. University of California, Publications in Geological Sciences 9(17):363–524.

———. 1917a. Climatic zones of Martinez Eocene time. California Academy of Sciences, Proceedings, ser. 4, 7: 193–196.

———. 1917b. Climate and its influence upon the Oligocene faunas of the Pacific Coast, with descriptions of some new species from the *Molopophorus lincolnensis* Zone. California Academy of Sciences, Proceedings, ser. 4, 7(6):157–192.

Dickinson, W.R. 1969. Geologic problems in the mountains between Ventura and Cuyama. Pages 1–23 *in* Dickinson, W.R., ed., Geologic setting of upper Miocene gypsum and phosphorite deposits, upper Sespe Creek and Pine Mountain, Ventura County, California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Field Trip Guidebook.

Dockery, D.T. 1980. The invertebrate macropaleontology of the Clarke County, Mississippi area. Mississippi Department of Natural Resources, Bureau of Geology, Bulletin 122, 387 pp.

Doncieux, L. 1903. Monographie géologique et paléontologique des Corbières Orientales. Annales d'Université Lyon, new ser., pt. 11:1–404.

Douvillé, H. 1904. Mollusques fossiles. Pages 191–380 in Morgan, J. de, Mission scientifique en Perse. Vol. 3, Études géologiques. Pt. 4, Paléontologie. E. Leroux, Paris.

———. 1916. Le Cretacé et l'Eocène du Tibet Central. Memoirs of the Geological Survey of India, Palaeontologia Indica, new ser., Memoir no. 5, 52 pp.

Douvillé, H., and G. O'Gorman. 1929. Description de la faune de Biron. Société Géologique de France, Bulletin, sér. 4, 29:329–390.

Dumble, E.T. 1912. Notes on Tertiary deposits near Coalinga oil field (California) and their stratigraphic relations with the Upper Cretaceous. Journal of Geology 20: 28–37.

Durham, J.W. 1942a. Reef corals from the California middle Eocene. California Academy of Sciences, Proceedings, ser. 4, 23(34):503–510.

———. 1942b. Notes on Pacific Coast Galeodeas. Journal of Paleontology 16(2):183–191.

———. 1950. Cenozoic marine climates of the Pacific Coast. Geological Society of America, Bulletin 61:1243–1264.

Durham, J.W., A.R.V. Arellano, and J.H. Peck, Jr. 1955. Evidence for no Cenozoic Isthmus of Tehuantepec seaways. Geological Society of America, Bulletin 66:977–992.

Eames, F.E. 1952. A contribution to the study of the Eocene in western Pakistan and western India; pt. C, Scaphopoda and Gastropoda. Royal Society of London, Philosophical Transactions, ser. B, 236(631):1–168.

Edwards, F.E. 1866. *Pyrula angulata.* Plate 4 *in* Lowry's chart of the characteristic British Tertiary fossils.

Eisenberg, L.I., and P.L. Abbott. 1985. Eocene lithofacies and geologic history, northern San Diego County. Pages 19–35 *in* Abbott, P.L., ed., On the manner of deposition of the Eocene strata in northern San Diego County. San Diego Association of Geologists, Volume and Guidebook.

Eschner, S. 1969. Geology of the central part of the Fillmore quadrangle, Ventura County, California. Pacific Section, American Association of Petroleum Geologists, Field Trip Guidebook. 47 pp.

Férussac, A.E. de. 1822. Tableaux systématiques des animaux mollusques. Paris. 111 pp.

Filewicz, M.V., and M.E. Hill. 1983. Calcareous nannofossil biostratigraphy of the Santa Susana and Llajas formations, north side Simi Valley. Pages 45–60 *in* Squires, R.L., and M.V. Filewicz, eds., Cenozoic geology of the Simi Valley area, southern California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Volume and Guidebook.

Finlay, H.J. 1927. A further commentary on New Zealand molluscan systematics. Transactions of the Proceedings of the New Zealand Institute 57:320–485.

Finlay, H.J., and J. Marwick. 1937. The Wangaloan and associated molluscan faunas of Kaitangata–Green Island subdivision. New Zealand Geological Survey Branch, Palaeontology Bulletin 15. 140 pp.

Fischer, A.G. 1966. Spatangoids. Part U, Echinodermata 3, pp. 543–628 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.

Fischer, P. 1880–1887. Manuel de conchyliologie et de paléontologie conchyliologique. F. Savy Librairie, Paris. 1369 pp.

Fisher, W.L., P.U. Rodda, and J.W. Dietrich. 1964. Evolution of the *Athleta petrosa* stock (Eocene, Gastropoda) of Texas. University of Texas Publication 6413. 117 pp.

Fleming, John. 1817–1821. Conchology. D. Brewster's Edinburgh enclopaedia. Several volumes.

———. 1822. The philosophy of zoology. Vol. 2. Edinburgh. 618 pp.

———. 1828. A history of British animals. 8 volumes. Bell and Bradfute, Edinburgh. 565 pp.

Forbes, E. 1838. Malacologia Monensis. A catalogue of the Mollusca inhabiting the Isle of Man and the neighboring sea. Edinburgh. 63 pp.

Frakes, L.A. 1979. Climate throughout geologic time. Elsevier, Amsterdam. 310 pp.

Frost, S.H., and R. L. Langenheim, Jr. 1974. Cenozoic reef biofacies: Tertiary larger foraminifera and scleractinian corals from Chiapas, Mexico. Northern Illinois University Press, De Kalb, Illinois. 388 pp.

Furon, R., and R. Soyer. 1947. Catalogue des fossiles Tertiaires du basin de Paris. Savior en Histoire Naturelle 22:1–240.

Gabb, W.M. 1864. Description of the Cretaceous fossils. Pages 55–243, pls. 9–32 *in* Meek, F.B., and W.M. Gabb, Palaeontology of California, Geological Survey of California, vol. 1, Palaeontology. Caxton Press, Philadelphia.

———. 1869. Cretaceous and Tertiary fossils. Geological Survey of California, vol. 2, Palaeontology. Caxton Press, Philadelphia. 299 pp., 36 pls.

———. 1873. On the topography and geology of San Domingo. American Philosophical Society, Transactions 15:49–259.

Gardner, J. 1912. The Midway Group of Texas. University of Texas Bulletin 3301. 403 pp.

———. 1926. The nomenclature of the superspecific groups of *Corbula* in the lower Miocene of Florida. The Nautilus 40:41–47.

———. 1931. Relation of certain foreign faunas to Midway fauna of Texas. American Association of Petroleum Geologists, Bulletin 15:149–160.

———. 1939. Notes on fossils from the Eocene of the Gulf Province. United States Geological Survey, Professional Paper 193B:17–33.

———. 1945. Mollusca of the Tertiary formations of northeastern Mexico. Geological Society of America, Memoir 11:1–332.

Gardner, J., and E. Bowles. 1934. Early Tertiary species of gastropods from the Isthmus of Tehuantepec. Journal of the Washington Academy of Sciences 24(6):241–248.

———. 1939. The *Venericardia planicosta* Group in the Gulf province. United States Geological Survey, Professional Paper 189F:1–196.

Givens, C.R. 1974. Eocene molluscan biostratigraphy of the Pine Mountain area, Ventura County, California. University of California, Publications in Geological Sciences 109:1–107.

———. 1978. An occurrence of the Tethyan genus *Volutilithes* (Gastropoda: Volutidae) in the Eocene of California. Journal of Paleontology 52(1):104–108.

———. 1979. The gastropod genus *Volutocristata* Gardner and Bowles (Eocene; California, Mexico): a synonym of *Lyrischapa* Aldrich (Eocene; Gulf Coast). Tulane Studies in Geology and Paleontology 15(4):117–127.

Givens, C.R., and M.P. Kennedy. 1976. Middle Eocene mollusks from northern San Diego County, California. Journal of Paleontology 50(5):954–975.

———. 1979. Eocene molluscan stages and their correlation, San Diego area, California. Pages 81–95 *in* Abbott, P.L., ed., Eocene depositional systems, San Diego, California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Field Trip Guide, Geological Society of America Annual Meeting.

Gmelin, J.F. 1778–1793. Linné's Systema Naturae. Editio 13, 3 vols.

Grabau, A.W. 1904. Phylogeny of *Fusus* and its allies. Smithsonian Miscellaneous Collections 44(1417):1–192.

Grant, U.S., IV, and H.R. Gale. 1931. Catalogue of the marine Pliocene and Pleistocene Mollusca of California. San Diego Society of Natural History, Memoirs 1:1–1036.

Grant, U.S., IV, and L.G. Hertlein. 1938. The West American Cenozoic Echinoidea. University of California at Los Angeles, Publications in Mathematical and Physical Sciences 2:1–226.

Gray, J.E. 1824–1828. Monograph of the Cypraeidae. Zoological Journal. 4 vols.

———. 1834. The animal kingdom arranged in conformity with its organization, by the Baron Cuvier, the Mollusca and Radiata. *In* Griffith, E., and E. Pidgeon. Whittaker, London.

———. 1837. A synoptical catalogue of the species in the collection of the British Museum. Pt. 1. Máctradae. Annals and Magazine of Natural History, ser. 2, 1:335, 370–376.

———. 1840–1842. Synopsis of the contents of the British Museum (Mollusca). British Museum, London.

———. 1847a. A list of the genera of Recent Mollusca, their synonyms and types. Zoological Society of London, Proceedings 15:129–219.

———. 1847b. The classification of the British Mollusca

by N.E. Leach, M.D. Annals and Magazine of Natural History 20:267–273.

———. 1849–1855. Catalogue of the Mollusca in the British Museum. British Museum, London.

———. 1857. A revision of the genera of some of the families of Conchifera or bivalve shells. Pt. 3, Arcadae. Annals and Magazine of Natural History, ser. 2, 19:366–373.

Gregorio, M.A. de. 1890. Monographie de la faune Eocénique de l'Alabama et surtout de celle de Claiborne de l'étage Parisien. Annales de Géologie et de Paléontologie, vols. 7 and 8. 316 pp.

———. 1894. Monographie des fossiles Eocéniques (Étage Parisien) de Mont Postale. Annales de Géologie et de Paléontologie 14:1–55.

Hanna, G.D. 1924. Rectifications of nomenclature. California Academy of Sciences, Proceedings, ser. 4, 13(10): 151–186.

Hanna, G.D., and L.G. Hertlein. 1939. *Campanile greenellum,* a new species from the early Eocene of California. Journal of Paleontology 13(1):100–102.

———. 1941. Characteristic fossils of California. California Division of Mines and Geology, Bulletin 118(2):165–182.

———. 1949. Two new species of gastropods from the middle Eocene of California. Journal of Paleontology 23(4):392–394.

Hanna, M.A. 1927. An Eocene invertebrate fauna from the La Jolla quadrangle, California. University of California, Publications in Geological Sciences 16(8):247–398.

Hantken, M. von. 1875. Neue Daten zur geologischen und palaeontologischen Kenntniss der südlichen Bakony. Mittheilungen Jahrbuch und Geologische Reichsanst 3: 339–371.

Haq, B.U. 1981. Paleogene paleoceanography: Early Cenozoic oceans revisited. Oceanologia Acta. Proceedings, 26th International Geological Congress, Geology of oceans symposium, Paris, pp. 71–82.

Haq, B.U., I. Premoli-Silva, and G.P. Lohmann. 1977. Calcareous plankton paleobiogeographic evidence for major climatic fluctuations in the Early Cenozoic Atlantic Ocean. Journal of Geophysical Research 82:3861–3876.

Harris, G.D., and K.V.W. Palmer. 1946. The Mollusca of the Jackson Eocene of the Mississippi embayment. Bulletins of American Paleontology 30(117):1–206.

Harris, G.F. 1897. Catalogue of Tertiary Mollusca in the Department of Geology, British Museum (Natural History), Pt. 1. The Australasian Tertiary Mollusca. London. 407 pp.

Hasson, P.F. 1985. New observations on the biostratigraphy of the Saudi Arabian Umm er Radhuma Formation (Paleogene) and its correlation with neighboring regions. Micropaleontology 31(4):335–364.

Heilprin, A. 1887. Explorations on the West coast of Florida, and in the Okeechobee wilderness, with special reference to the geology and zoology of the Floridian peninsula. Transactions of the Wagner Free Institute of Science of Philadelphia, 1:1–134.

Heller, P.L., and W.R. Dickinson. 1985. Submarine ramp facies model for delta-fed, sand-rich turbidite systems. American Association of Petroleum Geologists, Bulletin 69(6):960–976.

Hertlein, L.G. 1933. A new gryphaeoid oyster from the Eocene of California. San Diego Soeiety of Natural History, Transactions 7(22):277–282.

———. 1969. Family Peetinidae Rafinesque, 1815. Part N, Mollusca 6, Bivalvia, vol. 1, pp. 348–373 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.

Hertlein, L.G., and U.S. Grant, IV. 1972. The geology and paleontology of the marine Plioeene of San Diego, California (Paleontology: Pelecypoda). San Diego Society of Natural History, Memoir 2, pt. 2B, pp. 134–409, 31 pls.

Hickman, C.J.S. 1969. The Oligocene marine molluscan fauna of the Eugene Formation in Oregon. University of Oregon Museum of Natural History, Bulletin 16:1–112.

———. 1980. Paleogene marine gastropods of the Keasey Formation in Oregon. Bulletins of American Paleontology 78:1–112.

Hinds, R.B. 1843. Descriptions of new shells from the collection of Captain Sir Edward Belcher during the years 1836–1842. Zoological Society of London, Proceedings 11:36–49.

Hoagland, K.E. 1977. Systematic review of fossil and Recent *Crepidula* and discussion of evolution of the Calyptraeidae. Malacologia 16(2):353–420.

Houbrick, R.S. 1978. The family Cerithiidae in the Indo-Pacific. Pt. 1: The genera *Rhinoclavis, Pseudovertagus* and *Clavocerithium.* Monographs of Marine Mollusca, No. 1. 130 pp.

———. 1981. Anatomy, biology and systematics of *Campanile symbolicum* with reference to adaptive radiation in the Cerithiacea (Gastropoda: Prosobranchia). Malacologia 21(1–2):263–289.

Howell, B.F. 1962. Worms. Part W, Miseellanea, pp. 144–177 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.

Howell, D.G. 1974. Middle Eocene paleogeography of southern California. University of California Santa Barbara, Unpublished Ph.D. dissertation. 228 pp.

———. 1975a. Middle Eocene paleogeography of southern California. Pages 272–293 *in* Weaver, D.W., G.R. Hornaday, and A. Tipton, eds., Future energy horizons of the Paeific Coast; Paleogene symposium and seleeted technical papers. Ameriean Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, and Society of Economic Geologists, Pacific Sections, Annual Meeting.

———. 1975b. Early and middle Eocene shoreline offset by the San Andreas fault, southern California. Pages 69–74 *in* Crowell, J.C., ed., San Andreas fault in southern California. California Division of Mines and Geology, Speeial Report 118.

Ingram, W.M. 1940. A new *Gisortia*. Journal of the Washington Academy of Sciences 30(9):376–377.

———. 1942. Type fossil Cypraeidae of North America. Bulletins of American Paleontology 27(104):6–32.

———. 1947. Fossil and Recent Cypraeidae of the western regions of the Americas. Bulletins of American Paleontology 31(120):5–82.

International Commission on Zoological Nomenclature. 1985. International code of zoological nomenclature. International Trust for Zoological Nomenclature, 3rd ed. London. 176 pp.

Iredale, T. 1913. The generic name to be used for *Murex tritonis* Linné. The Nautilus 27:55–56.

———. 1915. Some more misused molluscan generic names. Malacological Society of London, Proceedings 11:170–178.

———. 1917. More molluscan name-changes, generic and specific. Malacological Society of London, Proceedings 12:322–330.

Isaeva, A.I. 1933. The gastropod fauna from the Eocene of Akhaltsikh. Transactions de Géologie Prospectus Service (USSR) 305:1–75.

Jackson, J.B.C. 1970. The ecology and paleoecology of near shore tropical Lucinacea (Bivalvia). Geological Society of America, Abstracts with Programs 7:586–587.

Jennings, C.W., and R.G. Strand. 1969. Geologic map of California, Los Angeles sheet (Olaf P. Jenkins edition). California Division of Mines and Geology, San Francisco. Scale 1:250,000.

Jestes, E.C. 1963. A stratigraphic study of some Eocene sandstones, northeastern Ventura basin, California. University of California, Los Angeles, Unpublished Ph.D. dissertation. 250 pp.

Joleaud, L. 1939. Atlas de paléobiogéographie. Paul Le-Chevalier, Paris. 99 pls.

Jousseaume, F.P. 1884a. Étude sur la famille des Cypraeidae. Société Zoologique de France, Bulletin 9:81–100.

———. 1884b. Division des Cypraeidae. Le Naturaliste 1884, p. 414–415.

Jung, P. 1974. A revision of the family Seraphsidae (Gastropoda: Strombacea). Palaentographica Americana 8(47):5–72.

Kappeler, K.A., R.L. Squires, and A.E. Fritsche. 1984. Transgressive marginal-marine deposits of the Avenal Sandstone, Reef Ridge, central California. Pages 9–27 *in* Blueford, J.P., ed., Kreyenhagen Formation and related rocks. Pacific Section, Society of Economic Paleontologists and Mineralogists.

Keen, A.M. 1951. The molluscan names in Reiner's "Tavole." The Nautilus 65(1):8–15.

———. 1969. Superfamily Veneracea Rafinesque, 1815. Part N, Mollusca 6, Bivalvia, vol. 2, pp. 670–690 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.

———. 1971. Sea shells of tropical West America (marine mollusks from Baja California to Peru), 2nd ed. Stanford University Press, Stanford. 1064 pp.

Keen, A.M., and H. Bentson. 1944. Check list of California Tertiary marine Mollusca. Geological Society of America, Special Papers 56:1–280.

Keen, A.M., and G. Johnson. 1960a. Superfamily Fissurellacea Fleming, 1822. Part I, Mollusca 1, pp. 226–231 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.

———. 1960b. Superfamily Trochacea Rafinesque, 1815. Part I, Mollusca 1, pp. 246–275 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.

Kennedy, W.J., N.J. Morris, and J.D. Taylor. 1970. The shell structure, mineralogy and relationships of the Chamacea (Bivalvia). Palaeontology 13(3):379–413.

Kennett, J.P. 1982. Marine geology. Prentice-Hall, Englewood Cliffs, New Jersey. 813 pp.

Kennett, J.P. et al. 1975. Cenozoic paleooceanography in the southwest Pacific Ocean, Antarctic glaciation, and the development of the circum-Antarctic current. Pages 1155–1169 *in* Kennett, J.P. et al., eds., Initial reports of the Deep Sea Drilling Project, vol. 29. United States Government Printing Office, Washington, D.C.

Kerr, P.F., and Schenck, H.G. 1928. Significance of the Matilija overturn (Santa Ynez Mountains, California). Geological Society of America, Bulletin 39(4):1087–1182.

Kew, W.S.W. 1920. Cretaceous and Cenozoic Echinoidea of the Pacific Coast region of North America. University of California, Publications in Geological Sciences 12: 23–236.

Kleinpell, R.M., and D.W. Weaver. 1963. Oligocene biostratigraphy of the Santa Barbara embayment, California. University of California, Publications in Geological Sciences 43:1–250.

Kobelt, W. 1877–1881. *In* Martini and Chemnitz, Neue Ausgabe. Nüremberg. Several volumes.

Koby, F. 1890. Monographie des polypiers jurassiques de la Suisse. Société Paléontologie Suisse, Mémoire 16:457–582.

Koenen, A. von. 1867. Über *Conorbis* und *Cryptoconus*, zwischenformen der Gattungen *Conus* und *Pleurotoma*. Palaeontographica 16:159–174.

Kriz, S.J. 1947. Stratigraphy and structure of the Whitaker Peak–Reasoner Canyon area, Ventura and Los Angeles counties, California. Princeton University, Princeton, New Jersey, Unpublished Ph.D. dissertation. 68 pp.

Laiming, B. 1940a. Some foraminiferal correlations in the Eocene of San Joaquin Valley, California. Sixth Pacific Science Congress, Proceedings 2:535–568.

———. 1940b. Foraminiferal correlations in Eocene of San Joaquin Valley, California. American Association of Petroleum Geologists, Bulletin 24:1923–1939.

———. 1943. Eocene foraminiferal correlations in California. California Division of Mines, Bulletin 118:193–198.

Lamarck, J.B. de. 1799. Prodome d'une nouvelle classification des coquilles. Mémoires de la Société d'Histoire Naturelle de Paris, pp. 63–91.

———. 1801. Système des animaux sans vertèbres ou ta-

bleau général des classes, des ordres, et des genres de ces animaux. Paris. 432 pp.
———. 1802–1809. Mémoires sur les fossiles des environs de Paris. Annales de Muséum National d'Histoire Naturelle, vols. 1–9, 12, 14. Variously paged. (Reprinted 1978 by Palaeontological Research Institution, Ithaca, New York.)
———. 1815–1822. Histoire naturelle des animaux sans vertèbres. 7 vols. Paris.
Lambert, J. 1902. Description des échinides fossiles de la province de Barcélone. Société Géologique de France, Paléontologie, Mémoire 24:1–128.
Latreille, P.A. 1825. Familles naturelles du règne animal, exposées succintement et dans un order analytique, avec l'indication de leurs genres. Second édition. Paris.
Lea, I. 1833. Contributions to geology. Carey, Lea, and Blanchard, Philadelphia. 227 pp.
Leymerie, A. 1878–1881. Description géologique et paléontologique des Pyrénées de la Haute-Garonne. É. Privat, Joulouse, pp. 1–1010.
Lightfoot, J. 1786. *In* A catalogue of the Portland Museum. London.
Link, H.F. 1807. Beschreibung der Naturalien-Sammlung der Universität zu Rostok. Vol. 1. Variously paged.
Link, M.H., and J.E. Welton. 1982. Sedimentology and reservoir potential of Matilija Sandstone: an Eocene sand-rich deep-sea fan and shallow-marine complex, California. American Association of Petroleum Geologists, Bulletin 66(10):1514–1534.
Linné, C. von. 1758. Systema naturae per regna tria naturae, Editio decima reformata, Regnum animale, vol. 1. Holmiae. 824 pp.
———. 1766–1767. Systema naturae per regna tria naturae, Editio duodecima, reformata, Regnum animale, vol. 1. Holmiae. 1327 pp.
Loel, W., and W.H. Corey. 1932. The Vaqueros Formation, lower Miocene of California. I. Paleontology. University of California, Publications in Geological Sciences 22: 31–410.
Lowe, R.T. 1827. On *Balanus punctatus, Puncturella flemingii,* etc., together with some corrections relative to *Turbo carneus,* and some of the chitons before described. The Zoological Journal 3:76–80.
Ludbrook, N.H. 1960. Scaphopoda. Part I, Mollusca 1, pp. 37–41 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.
Luyendyk, B.P. 1986. Neogene crustal rotations and translations in southern California: paleomagnetic evidence. Geological Society of America, Cordilleran Meeting (Abstracts) 18(2):128.
Maldonado-Koerdell, M. 1950. Faunas del Alto Cretacico superior, del Paleoceno y del Eoceno inferior y medio de Chiapas, Mexico. Anales de la Escuela Nacional Ciencias Biologicas Mexico 6(1–4):181–220.
Mallada, L. 1879. Sinópsis paleontólogica de España. Boletín Complilación Mapa de Geologica del España 6.
Marincovich, L.N., Jr. 1977. Cenozoic Naticidae (Mollusca: Gastropoda) of the northeastern Pacific. Bulletins of American Paleontology 70(294):169–494.
Marincovich, L.N., Jr., and W.J. Zinsmeister. 1985. Early Tertiary climates of the Arctic Ocean. Geological Society of America, Abstracts with Programs 17:653.
Marshall, W.B. 1917. The Wangaloa beds. New Zealand Institute, Transactions 49(38):450–460.
Mawe, J. 1823. The Linnaean system of conchology. London. 207 pp.
Mayer-Eymar, K. 1870. Tertiäre von Einsiedeln. Paris.
———. 1877. Systematisches Verzeichniss der Versteinerungen des Parisien de Umgegend von Einsiedeln. Beiträgen Geologisch Karte Schweiz 14(26):100 pp.
McLaughlin, R.P., and C.A. Waring. 1915. Petroleum industry of California. California Mining Bureau Bulletin 69. 519 pp. Atlas.
McLean, J.H. 1978. Marine shells of southern California. Natural History Museum of Los Angeles County, Science Series 24, revised ed. 104 pp.
Medlicott, H.B., and W.T. Blanford. 1879. A manual of the geology of India. Pt. 2, Extra-Peninsular India. Trubner and Company, London, pp. 445–817.
Meek, F.B. 1876. A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country. United States Geological Survey, Territory Annual Report 9:1–629, 45 pls.
Megerle von Mühlfeld, J.K. 1811. Entwurf eines neuen System's der Schalthiergehause. Magazin Gesellschaft Naturforschung Freunde Berlin 5(1):38–72.
Merriam, C.W. 1941. Fossil turritellas from the Pacific Coast region of North America. University of California, Publications in Geological Sciences 26(1):1–214.
Merriam, C.W., and F.E. Turner. 1937. The Capay middle Eocene of northern California. University of California, Publications in Geological Sciences 24(6):91–114.
Merriam, J.C. 1899. The Tertiary sea-urchins of middle California. California Academy of Sciences, Proceedings, ser. 3, 1(5):161–174.
Meyer, O., and T.H. Aldrich. 1886. The Tertiary fauna of Newton and Wautubbee, Mississippi. The Journal of the Cincinnati Society of Natural History 9(2):40–50, 64, pl. 2.
Miles, G.A. 1981. Planktonic foraminifers of the lower Tertiary Roseburg, Lookingglass, and Flournoy formations (Umpqua Group), southwest Oregon. Pages 85–103 *in* Armentrout, J.M., ed., Pacific Northwest Cenozoic biostratigraphy. Geological Society of America, Special Paper 184.
Milne-Edwards, H., and J. Haime. 1848. Notes sur la classification de la deuxième tribu de la famille des Astréides. Comptes Rendus d'lAcadémie des Sciences de Paris 27:490–497.
Montagu, G. 1803–1808. Testacea Britannica, or natural history of British shells, marine, land and freshwater. 2 vols. London. 789 pp.
Monterosato, T.A. di. 1884. Nomenclatura generica e spezifica di alcune conghiglie mediterranee. Palermo. 152 pp.
Montfort, P.D. 1810. Conchyliologie systématique et classification méthodique des coquilles. Vol. 2. F. Schoell, Paris, pp. 1–176.

Moore, E.J. 1968. Fossil mollusks of San Diego County. San Diego Society of Natural History, Occasional Paper 15, 76 pp.

———. 1983. Tertiary marine pelecypods of California and Baja California: Nuculidae through Malleidae. United States Geological Survey, Professional Paper 1228-A:1–108, 27 pls.

———. 1984. Tertiary marine pelecypods of California and Baja California: Propeamussiidae and Pectinidae. United States Geological Survey, Professional Paper 1228-B:1–112, 42 pls.

Mörch, O.A.L. 1852–1853. Catalogus conchyliorum quae reliquit D. Alphonso d'Aguirra et Gadea Comes de Yoldi. 8 vols., Hafniae.

———. 1858. Note sur le genre *Volutoharpa,* Fischer. Journal de Conchyliologie 7:40–44.

Morris, R.H., D.P. Abbott, and E.C. Haderlie. 1980. Intertidal invertebrates of California. Stanford University Press, Stanford. 690 pp.

Nelson, R.N. 1925. A contribution to the paleontology of the Martinez Eocene of California. University of California, Publications in Geological Sciences 15(11):397–466.

Newton, R.B. 1922. Eocene Mollusca from Nigeria. Geological Survey of Nigeria, Bulletin 3:1–140.

Nicol, D. 1950. Recent species of the lucinoid pelecypod *Fimbria.* Journal of the Washington Academy of Sciences 40(3):82–87.

Nilsen, T.H. 1973. Facies relations in the Eocene Tejon Formation of the San Emigdio and western Tehachapi Mountains, California. Pages 7–23 *in* Fischer, P.J., ed., Sedimentary facies changes in Tertiary rocks, California Transverse and southern Coast Ranges. Pacific Section, Society of Economic Paleontologists and Mineralogists, Field Trip Guidebook.

Nilsen, T.H., and E.H. Mckee. 1979. Paleogene paleogeography of the western United States. Pages 257–276 *in* Armentrout, J.M., M.R. Cole, and H. TerBest, Jr., eds., Cenozoic paleogeography of the western United States. Pacific Section, Society of Economic Paleontologists and Mineralogists, Paleogeography Field Guide No. 3.

Noetling, F. 1894. Note on the occurrence of *Velates schmideliana* Chemnitz and *Provelates grandis* Sow., sp., in the Tertiary formation of India and Burma. Records of the Geological Survey of India 27(3):103–108.

Okada, H., and D. Bukry. 1980. Supplementary modification and introduction of code numbers to the low-latitude coceolith biostratigraphic zonation. Marine Micropaleontology 5(3):321–325.

Olivi, A.G. 1792. Zoologica Adriatica. Bassano. Vol. 4. 334 pp.

Olsson, A.A. 1930. Contributions to the Tertiary paleontology of northern Peru. Pt. 3, Eocene Mollusca. Bulletins of American Paleontology 17(62):1–96.

Orbigny, A.D. d'. 1843. Paléontologie française. Terrains Crétacés 3:1–807.

Packard, E.L. 1916. Mesozoic and Cenozoic Mactrinae of the Pacific Coast of North America. University of California, Publications in Geological Sciences 9(15):261–360.

Page, B.M., J.G. Marks, and G.W. Walker. 1951. Stratigraphy and structure of the mountains northeast of Santa Barbara, California. American Association of Petroleum Geologists, Bulletin 35 (6):1717–1780.

Palmer, K.V.W. 1927. The Veneridae of eastern America. Cenozoic and Recent. Palaeontographica Americana 1(5): 209–522, 45 pls.

———. 1937. The Claibornian Scaphopoda, Gastropoda, and dibranchiate Cephalopoda of the southeastern United States. Bulletins of American Paleontology 7(32), pts. 1 and 2. 730 pp.

———. 1957. A new *Gisortia* from the Crystal River Formation, Ocala Group, of Florida, with explanatory notes on the Tethyan influence in the Floridian middle and upper Eocene. Journal of the Palaeontological Society of India 2:69–72.

———. 1967. A comparison of certain Eocene molluscs of the Americas with those of the western Tethys. Pages 183–193 *in* Adams, C.G., and D.V. Ager, eds., Aspects of Tethyan biogeography. Systematics Association Publication, no. 7.

———. 1974. Composition with relationships of Paleocene and Eocene molluscan fauna of the East Americas. Pages 468–485 *in* Contributions to the geology and paleobiology of the Caribbean and adjacent areas. Verhandlungen der Naturforschenden Gesellschaft in Basel, vol. 84.

Palmer, K.V.W., and D.C. Brann. 1965–1966. Catalogue of the Paleocene and Eocene Mollusca of the southern and eastern United States. Bulletins of American Paleontology 48:1–1057 (pts. 1 and 2).

Palmer, K.V.W., and H.G. Richards. 1954. Old World affinities of some Eocene mollusks from Florida. International Geological Congress, 19th session, 1952, 19: 35–38.

Parkinson, J. 1811. Organic remains of a former world. Pt. 3. Whittingham, London. 479 pp.

Parrish, J.T., A.M. Ziegler, and C.R. Scotese. 1982. Rainfall patterns and the distribution of coals and evaporites in the Mesozoic and Cenozoic. Palaeogeography, Palaeoclimatology, Palaeoecology 40:67–101.

Pilsbry, H.A., and A.A. Olsson. 1954. Systems of the Volutidae. Bulletins of American Paleontology 35(152):271–396.

Plaziat, J.-C. 1981. Late Cretaceous to late Eocene palaeogeographic evolution of southwest Europe. Palaeogeography, Palaeoclimatology, Palaeoecology 36:263–320.

Poli, G.S. 1791–1795. Testacea utriusque Siciliae, eorumque historia et anatomia. 3 vols. Parma.

Pomerol, C., and L. Feugueur. 1974. Bassin de Paris. 2nd éd. Guides géologiques régionaux. Masson et Cie, Paris. 216 pp.

Poore, R.Z. 1976. Microfossil correlation of California lower Tertiary section: a comparison. United States Geological Survey, Professional Paper 753-F:1–8.

———. 1980. Age and correlation of California Paleogene

benthic foraminiferal stages. United States Geological Survey, Professional Paper 1162-C:1–8.

Powell, A.W.B. 1942. The New Zealand Recent and fossil Mollusca of the family Turridae, with gencral notes on turrid nomenclature and systematics. Bulletin of Auckland Institute and Museum, no. 2. 188 pp.

———. 1966. The molluscan families Speightiidae and Turridae. Bulletin of the Auckland Institute and Museum, no. 5, 184 pp.

———. 1969. The family Turridae in the Indo-Pacific. Indo-Pacific Mollusca 2(10):215–415.

Quoy, J.R., and J.P. Gaimard. 1826–1834. Voyage de la corvette l'Astrolabe. Zoologie. Vol. 3. Paris.

Rafinesque, C.S. 1815. Analyse de la nature, ou tableau de l'univers et des corps organisées. Palermo.

Récluz, C.A. 1843. Catalogue descriptive de plusieurs nouvelles espèces de coquilles de France. Revue Zoologique par la Société de Cuviérienne. Vol. 6.

———. 1848. Description de coquilles nouvelles. Revue Zoologique par la Société Cuviérienne 11:275.

Reinhart, P.W. 1943. Mesozoic and Cenozoic Arcidae from the Pacific slope of North America. Geological Society of America, Special Paper 47:1–117.

Richards, H.G., and K.V.W. Palmer. 1953. Eocene mollusks from Citrus and Levy counties, Florida. Florida Geological Survey Bulletin 35:1–95.

Risso, J.A. 1810–1826. Histoire naturelle des principales productions de l'Europe méridionale et particulièrement de celles des environs de Nice et des Alpes maritimes. 5 vols. Paris.

Rodda, P.U., and W.L. Fisher. 1964. Evolutionary features of *Athleta* (Eocene, Gastropoda) from the Gulf Coastal Plain. Evolution 18(2):235–244.

Röding, P.R. 1798. Museum Boltenianum sive catalogus cimeliorum e tribus regnis naturae quae olim collegerat. J.F. Bolten, M.D., ed. Pars Secunda. Typis Johan Christi Trappii, Hamburg. 199 pp.

Römer, E. 1857. Kritische Untersuchung der Arten des Molluskengeschlechts *Venus* bei Linné und Gmelin mit Berücksichtigung der später Beschriebenen Arten. J. Georg Luckhardt, Cassel. 136 pp.

Roush, K. 1986. Depositional environments of the Eocene Domengine Formation, near Coalinga, Fresno County, California. California State University, Northridge, Unpublished M.S. thesis. 99 pp.

Ruth, J.W. 1942. The molluscan genus *Siphonalia* of the Pacific Coast Tertiary. University of California, Publications in Geological Sciences 26(3):287–306.

Sacco, F. 1890–1904. I molluschi dei terreni Terziari del Piemonte e della Liguria. Musei de Zoologia ed Anatomia Comparata della R. Universita di Torino, Bollettino pts. 7–30. [A continuation of work begun by Luigi Bellardi.]

Sage, O.G., Jr. 1973. Paleocene geography of southern California. University of California, Santa Barbara, Unpublished Ph.D. dissertation. 250 pp.

Saul, L.R. 1983. Notes on Paleogene turritellas, venericardias, and molluscan stages of the Simi Valley area, southern California. Pages 71–80 *in* Squires, R.L., and M.V. Filewicz, eds., Cenozoic geology of the Simi Valley area, southern California. Pacific Section, Society of Economic Paleontologists and Mineralogists.

Scanlin, D.G. 1958. Geology of the basal Modelo unconformity, Canton Canyon area, Los Angeles County, California. University of California, Los Angeles, Unpublished M.A. thesis. 74 pp.

Schafhäutl, K.E. 1863. Süd-Bayerns Lethaea Geognostica. Leipzig von L. Voss, London. 487 pp.

Schenck, H.G. 1926. Cassididae of western America. University of California, Publications in Geological Sciences 16(4):69–98.

———. 1936. Nuculid bivalves of the genus *Acila*. Geological Society of America, Special Paper 4:1–149.

Schilder, F.A. 1927. Revision der Cypraeacea (Mollusca Gastropoda). Archiv für Naturgeschichte 91 (für 1925). 171 pp.

———. 1967. The generic classification of cowries. The Veliger 10(3):264–273.

Schmidel, C.C. 1793. Vorstellung einiger merkwürdigen Versteinerungen, mit kurzen Anmerkungen, Pt. 2, 2nd. ed. J.J. Palm, Erlangen. 45 pp.

Schmidt, F.C. 1818. Versuch über die beste Einrichtung zur Aufstellung, Behandlung und Aufbewahrung der verschieden Naturkörper und Gegenstande der Kunst. Gotha. 252 pp.

Schumacher, C.F. 1817. Essais d'un nouveau système des habitations des vers testacés. 4 vols. Copenhagen. 287 pp.

Scott, K.M., J.R. Ritter, and J.M. Knott. 1968. Sedimentation in the Piru Creek watershed, southern California. United States Geological Survey, Water-Supply Paper 1798-E:1–48.

Shepard, G.L. 1960. Geology of the Whitaker Peak–Canton Canyon area, southern California. University of California, Los Angeles, Unpublished M.A. thesis. 64 pp.

Siesser, W.G. 1984. Paleogene sea levels and climates: U.S.A. eastern Gulf Coastal Plain. Palaeogeography, Palaeoclimatology, Palaeoecology 47:261–275.

Siesser, W.G., B.G. Fitzgerald, and D.J. Kronman. 1985. Correlation of Gulf Coast provincial Paleogene stages with European Standard ages. Geological Society of America, Bulletin 96:827–831.

Smith, J.P. 1919. Climatic relations of the Tertiary and Quaternary faunas of the California region. California Academy of Sciences, Proceedings, ser. 4, 9(4):123–173.

Smith, J.T. 1970. Taxonomy, distribution, and phylogeny of the cymatiid gastropods *Argobuccinum, Fusitriton, Mediargo,* and *Priene*. Bulletins of American Paleontology 56:445–573.

———. 1975. Age, correlation, and possible Tethyan affinities of mollusks from the Lodo Formation of Fresno County, California. Pages 464–483 *in* Weaver, D.W., G.R. Hornaday, and A. Tipton, eds., Future energy horizons of the Pacific Coast; Paleogene symposium and selected technical papers. American Association of Petroleum Geologists, Society of Economic Paleontologists

and Mineralogists, and Society of Economic Geologists, Pacific Sections, Annual Meeting.

Solander, D.C. 1766. Description of species. Pages 1–43 *in* Brander, G., Fossilia Hantoniensia collecta, et in Museo Britannico deposita. London.

Sowerby, G.B. 1820–1834. The genera of Recent and fossil shells, for the use of students in conchology and geology. 2 vols. London.

———. 1842–1887. Thesaurus conchyliorum, or monographs of genera of shells. 5 vols. London.

Sowerby, J. 1812–1845. The mineral conchology of Great Britain. 7 vols. B. Meredith, London. 648 pp.

Spengler, L. 1794–1802. Over det taskallede slaegt tellinerne. 5 vols. Skriv. Naturhist. Selskabet., Copenhagen.

Squires, R.L. 1976. Middle Eocene molluscan assemblage and stratigraphy, lower Piru Creek, Transverse Ranges, California. Geological Society of America, Cordilleran Meeting (Abstracts) 8(3):410–411.

———. 1977. Middle Eocene molluscan assemblage and stratigraphy, lower Piru Creek, Transverse Ranges, California. California Division of Mines and Geology, Special Report 129:81–86.

———. 1983a. New mollusks from the lower middle Eocene Llajas Formation, southern California. Journal of Paleontology 57(2):354–362.

———. 1983b. Eocene Llajas Formation, Simi Valley, southern California. Pages 81–95 *in* Squires, R.L., and M.V. Filewicz, eds., Cenozoic geology of the Simi Valley area, southern California. Pacific Section, Society of Economic Paleontologists and Mineralogists.

———. 1984. Megapaleontology of the Eocene Llajas Formation, Simi Valley, California. Los Angeles County Natural History Museum, Contributions in Science, no. 350. 76 pp.

———. 1985. New occurrences of the Tethyan gastropod *Velates perversus* in the early Eocene of California. Western Society of Malacologists, Annual Report 18:28.

———. 1986. Early Eocene, a time of influx of Old World Tethyan gastropods into the Pacific Coast of North America. Geological Society of America, Abstracts with Programs 18(2):188–189.

Squires, R.L., and D.M. Advocate. 1986. New early Eocene mollusks from the Orocopia Mountains, southern California. Journal of Paleontology 60(4):851–864.

Squires, R.L., and D.A. Yamashiro. 1986. A new occurrence of lower Eocene ("Capay Stage") strata, lower Piru Creek, Topatopa Mountains, southern California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Annual Meeting (Abstracts), Bakersfield, pp. 39–40.

Stanley, S.M. 1970. Relation of shell form to life habits in the Bivalvia (Mollusca). Geological Society of America, Memoir 125:1–296.

———. 1986. Earth and life through time. W.H. Freeman and Company, New York. 690 pp.

Stanton, T.W. 1896. The faunal relations of the Eocene and Upper Cretaceous on the Pacific Coast. United States Geological Survey, Annual Report 17:1005–1060.

Stenzel, H.B., E.K. Krause, and J.T. Twining. 1957. Pelecypoda from the type locality of the Stone City Beds (middle Eocene) of Texas. University of Texas Publications No. 5704:1–237.

Stewart, R.B. 1927. Gabb's California fossil type gastropods. Academy of Natural Sciences of Philadelphia, Proceedings 78:287–447, pls. 20–32.

———. 1930. Gabb's California Cretaceous and Tertiary type lamellibranchs. Academy of Natural Sciences of Philadelphia, Special Publication 3:1–314, 17 pls.

———. 1946. Geology of Reef Ridge, Coalinga district, California. United States Geological Survey, Professional Paper 205-C:81–115, pls. 11–17.

Stinemeyer, E.H. 1974. The biostratigraphy of the Paleocene–Eocene Lodo Formation in the vicinity of Salt Creek, Fresno County, California. Pages 69–84 *in* Payne, M., ed., The Paleogene of the Panoche Creek–Cantua Creek area, central California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Field Trip Guidebook.

Stoliczka, F. 1870–1871. Cretaceous fauna of southern India. The Pelecypoda, with a review of all known genera of this class, fossil and Recent. Geological Survey of India, Palaeontologica Indica, ser. 6, 3:1–535.

Suter, H. 1917. Descriptions of new Tertiary Mollusca occurring in New Zealand, accompanied by a few notes on necessary changes on nomenclature. New Zealand Geological Survey, Paleontology Bulletin 5:1–93.

Swainson, W. 1820–1833. Zoological illustrations, 2 ser., London.

———. 1840. A treatise on malacology; or the natural classification of shells and shell-fish. Longman et al., London. 419 pp.

Swift, D.J.P. 1968. Coastal erosion and transgression stratigraphy. Journal of Geology 76:444–456.

Trechmann, C.T. 1923. The Yellow Limestone of Jamaica and its Mollusca. Geological Magazine 60:337–367.

Troschel, F.H. 1852. Verzeichniss der durch Herrn Dr. v. Tschudi in Peru gesammelten Conchylien. Archiv für Naturgeschichte 18(1):151–208.

Turner, F.E. 1938. Stratigraphy and Mollusca of the Eocene of western Oregon. Geological Society of America, Special Paper 10:1–130.

Vail, P.R., and J. Hardenbol. 1979. Sea-level changes during the Tertiary. Oceanus 22(3):71–79.

Van de Kamp, P.C. et al. 1974. Facies relations in the Eocene–Oligocene in the Santa Ynez Mountains, California. Journal of the Geological Society of London 130: 545–565.

Vaughan, T.W. 1919. Fossil corals from Central America, Cuba, and Porto Rico, with an account of the American Tertiary, Pleistocene, and Recent coral reefs. United States National Museum, Bulletin 103:189–524.

———. 1945. American Paleocene and Eocene larger foraminifera. Geological Society of America, Memoir 9(1): 1–175.

Verastegui, P. 1953. The pelecypod genus *Venericardia* in

the Paleocene and Eocene of western North America. Palaeontographica Americana 3(25):1–112.

Vignal, M.L. 1904. Liste des coquilles de la famille des Cerithidés recueilles par M. Ch. Gravier aux environs de Djibouti et d'Obock. Bulletin Muséum National d'Histoire Naturelle de Paris 10:354–359.

Vokes, H.E. 1935. The genus *Velates* in the Eocene of California. University of California, Publications in Geological Sciences 23(12):381–390.

———. 1936. Notes on *Ancilla* Lamarck. Geological Society of America, Proceedings for 1935:414.

———. 1939. Molluscan faunas of the Domengine and Arroyo Hondo formations of the California Eocene. Annals of the New York Academy of Sciences 38:1–246.

———. 1940. Paleoecology of the fauna of the Domengine Formation, middle Eocene, California. Sixth Pacific Science Congress, Proceedings 2:597–605.

———. 1969. Observations on the genus *Miltha* (Mollusca: Bivalvia) with notes on the type and the Florida Neogene species. Tulane Studies in Geology and Paleontology 7: 93–126.

———. 1980. Genera of the Bivalvia: a systematic and bibliographic catalogue (revised and updated). Paleontological Research Institution, Ithaca. 307 pp.

Wagner, R.J., and R.T. Abbott. 1978. Family Olividae. Pages 801–813, Pt. 18 *in* Wagner, R.J., and R.T. Abbott, Standard catalog of shells, 3rd ed. American Malacologists, Greenville, Delaware.

Waller, T.R. 1978. Morphology, morphoclines and a new classification of the Pteriomorpha (Mollusca: Bivalvia). Royal Society of London, Philosophical Transactions, Bulletin 284:345–365.

Waring, C.A. 1914. Eocene horizons of California. Journal of Geology 22(8):782–785.

———. 1917. Stratigraphic and faunal relations of the Martinez to the Chico and Tejon of southern California. California Academy of Sciences, Proceedings, ser. 4, 7(4): 101–123.

Watson, H. 1930. On the anatomy and affinities of *Plicatula.* Malacological Society of London, Proceedings 19: 25–30, pl. 5.

Weaver, C.E. 1905. Contribution to the palaeontology of the Martinez Group. University of California, Publications in Geological Sciences 4(5):101–123.

———. 1937. Tertiary stratigraphy of western Washington and northwestern Oregon. University of Washington Publications in Geology 4:1–266.

———. 1943. Paleontology of the marine Tertiary formations of Oregon and Washington. University of Washington, Publications in Geology 5(1–3):1–789.

———. 1953. Eocene and Paleocene deposits at Martinez, California. University of Washington Publications in Geology 7:1–102.

Weaver, C.E., and K.V.W. Palmer. 1922. Fauna from the Eocene of Washington. University of Washington Publications in Geology 1(3):1–56.

Weaver, C.E. et al. 1944. Correlation of the marine Cenozoic formations of western North America. Geological Society of America, Bulletin 55:569–598.

Wells, J.W. 1945. West Indian Eocene and Miocene corals. Geological Society of America, Memoir 9(pt. 2):1–25.

———. 1956. Scleractinia. Part F, Coelenterata, pp. 328–444 *in* Moore, R.C., ed., Treatise on invertebrate paleontology. University of Kansas Press, Lawrence.

Wenz, W. 1938–1944. Gastropoda. Vol. 6, 7 parts, pp. 1–1639 *in* Schindewolf, O.H., ed., Handbuch der Paläozoologie. Gebrüder Borntraeger, Berlin.

Weyl, R. 1980. Geology of Central America, 2nd ed. Gebrüder Borntraeger, Berlin. 371 pp.

White, C.A. 1889. On invertebrate fossils from the Pacific Coast. United States Geological Survey, Bulletin 51:1–102.

Wilmarth, M.G. (compiler). 1938. Lexicon of geologic names of the United States (including Alaska). United States Geological Survey, Bulletin 896(pt. 2):1245–2396.

Williams, P.F., and B.R. Rust. 1969. The sedimentology of a braided river. Journal of Sedimentary Petrology 39: 649–679.

Wolfe, J.A. 1977. Paleogene floras from the Gulf of Alaska region. United States Geological Survey, Professional Paper 997. 108 pp.

Wood, S.V. 1861–1871. A monograph of the Eocene bivalves of England. Vol. 1. J.E. Adlard, Bartholomew, England. 182 pp., 25 pls.

Wood, W. 1818–1828. Index testaceologicus. 8 vols. Privately published, London. 188 pp.

Woodring, W.P. 1928. Miocene mollusks from Bowden, Jamaica. Part 2, Gastropods and discussion of results. Carnegie Institute of Washington, Publication 385:1–564.

———. 1957. Geology and paleontology of Canal Zone and adjoining parts of Panama. United States Geological Survey, Professional Paper 306-A–D:1–452, 66 pls.

Woods, A.J., and L.R. Saul. 1986. New Neritidae from southwestern North America. Journal of Paleontology 60(3):636–655.

Woodward, B.B. 1892. On the mode of growth and the structure of the shell in *Velates conoideus,* Lamk., and other Neritidae. Zoological Society of London, Proceedings for 1892:528–540.

Woodward, S.P. 1851–1856. A manual of the Mollusca: or rudimentary treatise of Recent and fossil shells. John Weale, London. 330 pp.

Wrigley, A. 1940. The English Eocene *Campanile.* Malacological Society of London, Proceedings 24(3):97–112.

———. 1941. New species of Eocene Mollusca from the Isle of Wight. Malacological Society of London, Proceedings 24:161–168.

———. 1942. Eocene *Campanile.* Geological Association, Proceedings 53:108.

———. 1951. Some Eocene serpulids. Geological Association, Proceedings 62:177–202.

Yamashiro, D.A. 1987. Depositional environments of Eocene sandstones, lower Piru Creek, Los Angeles and Ventura counties, southern California. California State University, Northridge, Unpublished M.S. thesis, 157 pp.

Yamashiro, D.A., and R.L. Squires. 1986. Eocene marine

to nonmarine (deltaic) deposits, lower Piru Creek, Los Angeles and Ventura counties, California. Pacific Section, Soeiety of Economic Paleontologists and Mineralogists, Annual Meeting (Abstracts), Bakersfield, pp. 43.

Zinsmeister, W.J. 1974. Paleocene biostratigraphy of the Simi Hills, Ventura County, California. University of California, Riverside, Unpublished Ph.D. dissertation. 236 pp.

———. 1978. Review of the bivalve genus *Pholadomya* from the Tertiary of California and the description of two new species. The Veliger 21(2):233–235.

———. 1982. Late Cretaceous–early Tertiary molluscan biogeography of the southern circum-Pacific. Journal of Paleontology 56(1):84–102.

———. 1983a. Late Paleocene ("Martinez Provincial Stage") mollusean fauna from the Simi Hills, Ventura County, California. Pages 61–70 *in* Squires, R.L., and M.V. Filewicz, eds., Cenozoic geology of the Simi Valley area, southern California. Pacific Section, Society of Economic Paleontologists and Mineralogists.

———. 1983b. New late Paleocene molluscs from the Simi Hills, Ventura County, California. Journal of Paleontology 57(6):1282–1303.

———. 1985. Evidence for temperate conditions along the Antarctic Peninsula during the early Tertiary. Geological Society of America, Abstracts with Programs 17:758.

Zittel, K.A. von. 1900. Text-book of palaeontology, 1, Invertebrata. Macmillan, London. 706 pp.

———. 1913. Text-book of palaeontology, 1, Invertebrata. Macmillan, London. 839 pp.

Received 8 August 1986; accepted 13 March 1987.